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Loading the roots in the field.

Spreading the chopped root on the floor of the drying kiln.

THE MANUFACTURE OF CHICORY IN FRANCE.—[See page 41.]

Economy in Study*

Psychological and Physiological Points on How to Study to the Best Advantage

By George Van Ness Dearborn, M.D.

The fact must be frankly faced that it is possible that some two or three of you would be more useful to yourselves and the world in a nice "job," either on the front or on the back end of the street cars; or in a good, substantial position in a machine-shop, in a laundry, or in a confectionery store, or something like that. For it is possible, if not probable, that some of you are not of a scholarly "makeup" at all, so that you never could be a success as physicians. Now is the time to discover it, although a year at anatomy and physiology would in any event be of use to you.

Interest in the Subject.—If you are naturally of a scholarly disposition it is much easier to effectively study than otherwise it could be. But whether scholarly or not you must first have a real interest in that which you wish to study. If you have grown up without the "natural medical interest," it is your duty to acquire an interest in Medicine, but when you have really acquired a real *interest* you will learn almost reflexly and without any great effort on your part because it will be a *pleasure* to you. So this matter is truly worth while. Furthermore, you must have a continually changing and a continually developing interest, not only in Medicine as a whole, as a prospective life-profession, but interest in each of the forty or more subjects as they come along; in every case, if you wish to economize you will, as a preliminary, develop an interest in the subject you are studying. It was once facetiously claimed by Huxley that he could make a course in osteology interesting to anybody who studied it! It is absolutely necessary, then, in short, to have *interest*, natural or acquired.

The best way to develop an interest in any subject is by *collateral reading*. Read broadly on subjects allied more or less to what you are studying. When it is physiology, for example, you should read about related diseases, physics, psychology, and the enticing histology of the nervous system, for examples. Another way to develop interest is by *thinking* for yourself of those relations. A third method is to *associate with people* who already have an interest.

Whatever you have an interest in, you *enjoy* doing, and that is the reason why well-adapted work in the long run is the most certain, if not the greatest, of human delights. Many people think of work as a necessary something disagreeable rather than agreeable, but I repeat that it is certainly one of life's most permanent and substantial satisfactions and delights. Unpleasant undeniably is work that is not adapted to the individual. You do not often see professors in our universities and colleges grumbling about their work, and this is not primarily because their work on the whole is pleasant, but more often because it is well adapted to them; for else they give it up. It is the vast body of men who do not as yet have work which is adapted to them who do not like to work. All great, useful, and original work ordinarily is done under conditions such that the work is enjoyable, there being always enough interest about it to make it pleasurable. It is under these conditions, furthermore, and generally under these alone, that the largest amount of energy is expended. This basal relationship is expressed in the science of efficiency in the term "Sthen-euphoric Index," meaning, in short, the more or less direct ratio between the expenditure of *energy* in any action and its inherent *pleasantness*. "Enjoy your work and you will most likely expend a very large amount of energy in it." This is the practical corollary of this fundamental index of organic dynamics.

There are two kinds of learning as a procedure, one of which is a *conscious* process, conscious, deliberate study; while the second is another mode of learning, of which most of you are not even aware, namely, *subconscious* learning; in short, by observation and association, more or less unconscious.

Conscious or Deliberate Study.—When you think of study most of you, I am sure, consider only conscious, deliberate study, reading, or "grinding," usually in some book or other. This process, as you will understand next year better, is essentially a checking or restraining process, that which we call in physiology and in psychology "inhibition," an incentive of some sort to check some active process by a normal influence. The process of conscious study is one of an inhibitory nature.

In the first place you have to inhibit *fatigue*, when, you "grind." You are tired and would like to go to bed, or to go outside for a walk, or to some place of amusement that is restful. There should be no fatigue, theoretically. Your work should be so arranged, alternating with rest and exercise and eating, that there should be no appreciable and depressing fatigue. This inhibition of which we are speaking seeks a more *pleasant occupation*. Then there are many *distractions* which have to be inhibited: the reckless automobiles or carting on the avenue, cats or hyenas on the back fence, a piano-torture from the next room, or someone beyond all humanity trying to play on the violin. All sorts of *sensory stimuli* have to be kept out of your effective mind. The *desire to change* must be inhibited, the perfectly normal tendency to change your occupation and thus get rested.

Study, then, so far as deliberate, is the forcing of the mental processes along new pathways, the forcing of nerve-impulses perhaps through groups of thousands of neurones where exactly they have not been before. When interest is acquired and other things are right and you are in good physiological condition, it is a real pleasure to truly grind. The habit of even this kind of study is easily acquired, much more easily in most of you than you think.

Beware of *false study*, dozing: trying to hold your eyes open while your brain is shut tight. In such cases your brains are not open, for the sensory paths and the association paths are closed. If your interest or attention cannot be forced on what you are studying, you should wholly rest for a few minutes or else open the windows, stir about, and force the issue! Or, if conditions are such that you cannot possibly give your attention to your subject, as in fatigue readily may happen, give it up. Unless you give your whole attention to whatever you are studying it is of little or of no account to you, and much worse than that, it gets you into the bad habit of sitting with a book in front of you and pretending to yourself (and sometimes to your teachers) that you are studying when in reality your brain-neurones are not getting hold on the facts at all. The loss of a little time is of no account compared with the misfortune of this habit.

There should be *no rote-learning*. There are only extremely few things that are properly learned by rote, and it is well to avoid attempting to learn in this way. In the long run it is a great waste. Facts and principles should be learned by concept, not by word.

There are certain physiological requisites for study, especially five things of a hygienic physiological nature which must be mentioned: namely (1) good health, (2) abundant outdoor muscular exercise, (3) abundant natural air, (4) abundant proper food, and (5) abundant sleep.

It is necessary for a student to have *good health*, else he is inexcusably wasteful. One cannot possibly study, for example, with *eye-strain*, for this inflicts a continuous strain on the brain and on the whole nervous system, which depresses the vigor of the mental action. Students should not think of studying when they have a *headache*, in which condition the brain is congested with blood. For a like reason, one should not try to study when he is *ill*, say with a bad cold in the head, even a mild influenza, or anything of that sort. It is very necessary that a successful student should be *free from worry*.[1] If worrying interferes with your business of studying, either give up worrying or postpone your business, for certainly you cannot do both at the same time. In some cases study can be made to force the worry out of your head; if so, it is well.

Take *abundant gross muscular exercise*. The reason for this is that exercise stimulates the circulation, and "keeps the cobwebs out of the brain," the spinal cord, and other important nerve-masses. Muscles, as well as brains, are used in thinking, and they don't work as well when they are flabby and out of tone, and poorly supplied with oxygen and clogged with carbon dioxide. Too much exercise, on the other hand, must be avoided, since it employs the brain and so tires it beyond use for study.

Abundant Natural Outdoor Air.—It is not necessary to study out of doors, as you can have plenty of outdoor air indoors by the simple expedient of opening the windows. Air of the proper temperature and proper humidity is essential. Moving air, properly moist and properly *cool* (68 deg. F.), is the ideal.[2]

Have *abundant food*, but not too much. The ideal is food that is easily digestible and taken often. Four moderate meals a day is far better for a student than two over-large. Coffee may be taken if necessary for successful study. There are many authors who do good and abundant creative work under the influence in general only of tea or of coffee, essentially alike in their stimulant action. I do not suggest alcohol, for it is a poisonous depressant and not a stimulant at all, save indirectly on the heart.

Students to be efficient must have *abundant sleep*. Ten hours is little too much. There must be no study within an hour, at least, after eating. Gentle ambulatory exercise helps digestion, on the other hand. It is certain that if the blood is in the stomach doing its work there, enough of it cannot be at the same time in the brain, and your brain cannot work without its normal abundance of blood. So that it is quite absurd to think of studying to good advantage immediately after a hearty meal. It is by many considered a good thing at times through the day to take cat-naps. Food digests best of all when you are asleep. Do not try to carry on your work on the boa constrictor plan of taking one big meal every six months and then going to sleep for the next six months! The boa constrictor is a poor student. Ten hours sleep is none too much and cat-naps certainly are excellent, for a short nap, even of five or ten minutes, gives one a large amount of cerebral rest, for even a five-minute nap takes the blood for a moment out of the brain, stirs things up there generally, and makes one ready for a good siege of study.

Attention to a book should *not* be *too long concentrated*, without pause. It should by habit be concentrated vigorously, but only for relatively short periods at a time. There should be more power of concentration for short periods than most high schools inculcate, but one cannot keep his mind strongly concentrated for long periods under ordinary degree of educational interest. Every twenty minutes or so you should walk around the room for a minute or two, for this activity draws some of the blood out of your brains into your legs; moreover, it relieves the injurious long fixation of the eyes. No one can sit for an hour, or an hour and a half, without changing his position, except at a considerable loss of nerve-economy, and it is under such a condition naturally difficult to avoid going to sleep, partial or complete.

Grammar schools and high schools almost never as yet succeed in teaching their students *how to think*, and yet that is what counts most. A momentary, thoughtful idea often is worth a week of fruitless mechanical grind, just as one large highly-cultivated Gravenstein is worth a whole barrel of crab-apples. Quality not quantity is what counts in study as well as in other things. Make a serious business of it, then, when you study, remembering that real learning, that is understanding and constructive power, comes only through thought.

Subconscious Learning.—This is a mode of learning which one unfamiliar with psychology is not apt to think of as "study" at all. You require this kind of learning (both as process and as product) with your subconscious minds, physiologically chiefly, the association of millions of neurones. Subconscious observation by your subconscious minds would be a common way to characterize it.

A good example of this kind of study or learning is a child about two years old learning to speak. The child of course, does not at first consciously strive to pick up the marvelous art of speaking, but none the less he acquires it quickly, in part by imitation. You cannot understand anything worth learning without this factor of mind, the subconscious mind, the great integrator of intelligence. The endless details of knowledge are supplied very largely by this unconscious mental process, this continual subconscious perception and observation by all the senses at once.

It is beyond our present range to describe this phase of human mind, that deep and on-rushing part of "the stream of consciousness," which is closest to the nervous integrators of protoplasmic function. It is the great planner of our behavior, however, the chief solver of our most important problems in the conduct of life; it is the seat of our motives, the developer of our habits, the associator of our ideas into real and useful knowledge. I recommend it to you for study, that you may understand your own self and the minds of those about you, your future patients especially. (Von Hartmann, Dubois, H. Poincaré, Morton Prince, Ribot, Janet, will teach you about it, all that you need to know, until you observe its phenomena first hand for yourselves.)

At present we are concerned with the subconscious as the chief active recipient of information from the environment and as the chief arranger, developer, and increaser of this ever-varying multitude of educational impressions. As has been said already, without the subconscious there could be no real understanding of actual conditions of experience at all, so myriad are they and so complex and interinvolved.

There are three chief ways of studying in this process of collegiate learning. In the first place, by more or less

*Remarks made for the most part, to the Premedical Class of the Tufts College Medical School, Boston, March 8, 1915.

[1] See, for the therapeutics of worry and nerve-waste in general, a little monograph called "Nerve-Waste," Health Education League Booklet, No. 27, Boston, 1912.

[2] For a discussion of the need of moving air and of other hygienic conditions, see the lecturer's "Certain Further Factors in the Physiology of Euphoria," *Psychological Review*, XXI, 3, May, 1914, 166–188, illustrated.

conscious seeing and observing of books, diagrams, pictures, and other things that you can get only through your sense of vision. Second, *hearing* things with your ears, such as lectures, recitations, and talk. And third, by actually actively *doing* things—extensive laboratory work, clinical work, and to a much less extent essay-work, constructive drawing, research. To discuss these within the hour is out of question, so that we must be content with the mere observation, although of basal and vast importance, that *doing*, as opposed to receiving, represents the modern method of learning even the most abstract of subjects. The world is becoming aware, and effectively aware, that bodily efficiency one way or another is the basis of learning, or, in the words of wise old Pestalozzi, "Keine Kentnisse ohne Fertigkeiten!"—that is, No knowledge without skill.

Imagination is essential in every scientific man who is more than a manikin. But *visualizing imagination* is of immediate necessity to every student and especially to the student of any individual branch of biology. You must be able to look, in your minds, directly into any part of a living organism and accurately see just what there is and precisely what is going on there. The lack of this power, I am convinced, is the cause of the inefficiency of many physicians. Anatomy, histology, physiology, pathology, clinical surgery, clinical medicine are but impractical knowledge without this faculty.

The taking of notes is of sufficient importance practically to warrant a few minutes of discussion. If textbooks are the meat of the student, his notes are certainly his necessary drink, with his meals and at other times. It has been said that one "should train their power of observation and memory" so as to be able to go into a lecture room and get the gist of the lecture without taking notes. But in the first place, we cannot develop our memory.[3] Born with a certain kind and perfection of memory we cannot increase its effective span. Every lecture in a professional school contains many material facts, and sometimes hundreds of them, and there is no mind that can remember them all, *economically*. No matter how vital and permanent they may seem the moment when you hear them, they probably are soon replaced with others equally interesting, and very soon most of them are gone, many of them for good, while part of those which remain are jumbled and mistaken.

Take notes of everything worth noting. No matter where you are, whenever you hear anything, or even see anything worth noting, "make a note of it." These notes will be of value to you all your life, the most vital links of your mind with your precious college life; and often of great practical use.

Notes should be schematically arranged in a psychologically scientific way, with center headings, side headings, group headings, and subgroup headings, and put down according to *ideas* under such headings. When all run together notes are not of much use. One should get into the habit of using abbreviations. Shorthand is very desirable, economical, and almost necessary, but if you cannot manage to learn shorthand, acquire a system of abbreviation of your device. Do not expect, as I have said already, to get from a lecture anything that you can take down and run in verbatim on an examination, for a good lecture is an explanation, not dictation, not a description, and not a set of crib notes.

It is extremely important to economy that you should keep your notes "posted up" every day, not only in your notebooks, but in your brains. Go over your notes in general every night and connect them with what has gone before, and so keep your mind up with the subject. *Examinations will take care of themselves* if you keep your didactic material posted up day after day. Examinations are not intended to trap you, but are intended as means to find out how much you know or do not know; mostly, in fact, how much you do *not* know. Cramming for an examination is like carrying weights in your pockets when getting weighed: you are cheating yourself. The economical way is to keep your notes posted up in your books and in your brains every day; so, they can associate and you learn much faster, giving your subconscious faculties a better chance. The power of grasping *ideas* is an extremely valuable one. Pick out the gist and sense of a running discourse, select the ideas and express them in your own words.

The drawing and writing of diagrams is of the greatest importance, and all put before you should be quickly sketched. The drawing of original diagrams is of much value to you, but the quick copying of those put before you is also very important. Things should not "go in one ear and out the other": there should be something within, between, them to fix the ideas, namely, your brains, and one easy way to do that is writing tersely the ideas, and drawing the diagrams whenever possible. You should, as has been said, learn to visualize, to see things in your mind, and this selection of the essentials will help this important habit.

Frequent reviewing is of the greatest importance. It tends to integrate things, keeps subjects unified, and puts the whole subject before you at once; without a wholeness nothing is of much account.

You should have *as large a variety of textbooks* as you can possibly afford on every subject you study, for, in that way, you get different points of view of the same topic and fixation is more certain. Every ten dollars paid for good books while you are a student will be worth a hundred dollars to you later on. And no wise person sells his old textbooks, for each one has associations with his mind which make it often far more valuable and convenient to him in later years than a new one could be.

Conversation and discussion among yourselves are extremely important as means to accurate and broad information. Talk things over. Collateral reading always lends interest, and makes you a better talker, which in itself is well worth while in a professional man or woman.

Finally, I will suggest that it is a great waste for you to live out of town so that you are obliged to ride for more than half an hour twice daily in the train or street cars. Considering all matters, cash, nerve wear-and-tear, danger, eye-strain, etc., it is certainly economy to live in town and pay board and lodging rather than at home if it be more than, say, twenty miles away.

[3] For an up-to-date brief account of memory see the article in a leading medical encyclopedia, the *Reference Handbook of the Medical Sciences*, third edition, volume six.

Gun-Primers and Detonators

A recent issue of the Italian *Rivista di Artiglieria e Genio* contains an article on gun-firing, which was written both to demonstrate the advantage there is in the use of black powder, instead of smokeless powder, for charging primers, and to put on record the work of various experts in regard to the manufacture of primers.

The explosives which deflagrate when they are lighted by a match in the open in small quantities, such, for example, as dynamite, nitrocellulose, the ammonium nitrate explosives, and in general, all the nitrated explosives, whether pure or mixed, require the use of a primer to develop their power. The explosives, on the other hand, which explode in contact with a flame, such as fulminate of mercury, nitride of lead, black powder, Berthollet powder (a potassium chlorate powder), only require a simple firing medium, such as a quick-match, a slow-match, a friction-tube, or a metallic cap containing a substance which can be set alight by shock or by an electric spark.

Priming at first resolved itself into the placing of powder in the pan; this powder was set alight by the flint, and it fired the charge. The present-day primer, due to the use of smokeless powders, has a different function, and may be considered as a device for governing the intensity of the initial shock and as a means to secure the complete explosion or detonation of the powder charge.

Gun-primers consist of a copper or brass cap filled with a mixture capable of being ignited by a shock, and of a priming charge; this may be black powder or smokeless powder, and it causes the gun-charge to explode. According as black powder or smokeless powder is selected for the priming charge, the function of the cap varies, since black powder behaves quite differently from smokeless powder. The experiments carried out by Roux and Sarrau showed that most explosives, nitroglycerine, nitrocellulose, picric acid, etc., explode or detonate according to the method in which they have been treated, and that black powder, which is commonly granulated, always explodes, both under the action of a match or under that of a cap of fulminate of mercury; it can be made to detonate only with a primer of fulminate and nitroglycerine, and by detonating its effects are considerably increased.

At this point, the author of the article, Mr. Guido Finzi, chief chemist of the Italian Corps of Artillery and Engineers, explains the meaning of the terms "deflagration," "explosion," and "detonation." A deflagration is a sharp reaction accompanied by a flame and a strong concussion; it is produced when a small amount of explosive, such as guncotton, ballistite, etc., is fired in the open by a flame. An explosion is a violent reaction accompanied by a flame, and a sharp noise; it occurs when black powders, or when smokeless powders, are placed in a closed receptacle, or between partitions which can give way, and are lighted by a slow-match, a quick-match, or a flame. A detonation is the most violent explosion which can be obtained with a given explosive; it occurs when adding to the lighting medium—flame or electric spark—a suitable primer.

When using black powder for charging the primer, for exploding which a flame is sufficient, the function of the fulminating cap is reduced to that of a simple igniting agent. If, on the other hand, the priming charge consists of smokeless powder, for which a simple igniting agent is not sufficient, the function of the cap is that of a real primer, which has to cause the explosion of the priming charge, which latter, in this instance, transmits and multiplies the effects produced by the cap. The quality and the quantity of the fulminating mixture in the cap are of great importance when the charge in the primer is smokeless powder, since, if the fulminating composition is too weak, it will only promote the deflagration of the charge in the primer; if too violent, it will promote its detonation, and it has to be so regulated as to promote the entire explosion of the charge, a condition which is difficult to obtain in practice.

The explosion of the gun-charge is produced by the shock and the pressure which the products developed by the decomposition of the priming charge exert against it. The shock is due to the dynamic energy, or *vis viva*, which animates the new products formed, and is represented by the well-known formula, $\frac{1}{2} m v^2$, where m is the mass of the new products, and v their velocity. The pressure is a static phenomenon due to the volume of the gases developed and to the great rise in temperature. In his *étude* on explosives, published in the *Moniteur Scientifique* for November, 1906, Bickel demonstrated that the effects produced by an explosion—i. e., the shock and pressure above referred to—do not act at one and the same time, there being between the two phases of the phenomena an interval of 5/100 second; the shock effect acts first, followed by the pressure effect. The charge in the primer being small, and the space in the powder-chamber of the gun being comparatively large, the effects of the primer due to the pressure, which has a tendency to decrease by loss of heat through the gases coming in contact with cold surfaces, may be considered very limited, if not nil, and the explosion of the gun-charge is due solely to the shock effects. The decomposition of the charge in the primer gives rise to new bodies of varied specific gravity, which transmit to the gun-charge shocks of more or less intensity, the component shock being the one represented by the above formula.

The smokeless powders are transformed into gases and vapors, while black powder is transformed into gas and solid bodies. The solid bodies formed on the explosion of black powder—potassium carbonate, potassium monosulphide, and potassium sulphate—amount to 57 per cent of the products of the decomposition, and have a specific gravity much above that of the gases and vapors formed on the explosion of smokeless powders. With primers charged with black powder there is, therefore, obtained (*a*) a more uniform firing of the gun-charge, and the avoidance, at the same time, of the risk of causing it to detonate or to explode incompletely; (*b*) the shock for exploding the gun-charge gives rise to much lower pressures and temperatures, and the risk of deforming the primer-case is decreased, thus eliminating the difficulty of unscrewing it after the round is fired, a difficulty which is encountered with most of the primers when primed with a smokeless powder; and (*c*) the possibility of reducing to a minimum the strength of the fulminating mixture in the cap, this acting as a simple igniting device.

Detonators are the very powerful primers used for firing the charge of bursting shells, mines, etc. Until quite recently, fulminate of mercury has been used exclusively for priming. This substance, whatever means be taken to promote its decomposition, detonates, both in a closed space or in the open, with such violence that, presumably, it decomposes before the new products formed, a part of which have a high specific gravity, have had time to dilate. By detonating, it produces a shock capable of causing the explosion or detonation, not only of guncotton, dynamite, etc., but also of bodies which, although they had been known for a long time, had hitherto been considered inert substances, such, for example, as trinitrophenol, one of the most potent explosives of modern times. The maximum charge in detonators does not exceed two grammes. When this charge is not sufficient to obtain the required result, such, for example, as with large explosive shells, it is necessary to add to the detonators an intensifying medium, which is proportioned to the quantity of explosive to be detonated. This medium consisted, at first, of dry cotton-powder, which, later on, was replaced by picric acid, as this is practically insensible to shocks; picric acid is being in its turn, replaced by trinitrotoluol, also called trotyle, trilite, and tolite, because this substance, while it has the quality of picric acid, also has the advantage of not giving rise to the formation of compounds of a similar nature to picrates, which are dangerous, owing to their great sensibility to shocks. The velocity of detonation of fulminate of mercury and of trotyle varies, according to different experimentalists, between 6,500 and 7,200 meters per second. The velocity of decomposition of ordinary explosives is much lower; it does not exceed generally 3,000 meters. That of gelatine, for example, is of about 2,000 meters per second.

Fulminate of mercury is now being replaced for priming detonators by a new substance, a derivative of hydronitric acid (HN_3), improperly called nitride of lead, the chemical formula of which is PbN_6. Its sensibility to shocks may be considered equal to that of fulminate of mercury. On exploding it gives out an amount of gases less than does fulminate of mercury, but has a velocity of decomposition greater than the velocity of decomposition of fulminate. Its feature is that it detonates even when damp.—*Engineering*.

A Radio Generator for Amateurs

Instructions for Fitting Up a Powerful and Efficient Source of Current

By Frederick E. Ward

Although under the present laws relating to wireless telegraphy amateurs are permitted to use generators of as much as one kilowatt capacity, only a few of the licensed stations are provided with apparatus of anywhere near this power. Doubtless in many cases this is because of the fact that an alternating current generator of this size is too costly for the average experimenter to buy and too difficult for him to build in his home workshop.

Probably it has not occurred to many that an ordinary commercial induction motor may be converted into a good generator for radio-telegraphy with but comparatively little machine work and no very great labor. Such a motor may be purchased in most any large city from the second-hand dealers in electrical machinery, and need cost but little money because it need not be in good condition. If the rotor is damaged or the stator winding is burned out it makes no difference, since the stator must be rewound anyway and an entirely different kind of rotor will have to be made. In selecting a motor, however, certain points of design must be borne in mind. Thirty-six slots are required in the stator, and the teeth must be of the T head form shown in Fig. 1, nearly inclosing the slots and leaving but narrow slits in the tops of the latter. A diameter of about 5 inches is needed in the bore, with an axial length of about 3 inches in the laminated iron portion.

A frame of this size, when provided with a twelve-pole stator winding and a twelve-pole revolving field, excited by direct current and driven at 2,400 revolutions per minute, will have a continuous output capacity of one half kilowatt at 80 per cent power factor and an intermittent capacity of one kilowatt. The frequency of the above, which is 240 cycles, is one that works out satisfactorily in many ways. It is low enough to avoid design difficulties and yet high enough to give a sound of pleasing pitch in the receivers, and also permits of the working at one kilowatt of ordinary types of apparatus designed for ½ kilowatt at 60 cycles.

With the exception of one operation (that of slotting the rotor, which is best done on a milling machine at some nearby machine shop) the work of rebuilding a motor as outlined above is not too difficult to be done by anyone possessing a small screw-cutting lathe and having average skill in the use of tools. Because of the diversity of dimensions to be found among the various commercial motors, however, no drawings that will admit of universal application can be shown, but the following detailed description of the methods followed by the author, together with the test results obtained from the finished machine, will doubtless be helpful in solving many similar problems.

The different stages of rewinding the stator are shown in Fig. 1. Each coil is wound of 25 turns of No. 16 double cotton covered wire, the twelve coils being subsequently connected in series so as to give alternate polarities all around. It will be noted that each coil spans two teeth, leaving an empty slot between them. The slots that are to be filled are first lined with an insulating tube, formed by wrapping four turns of varnished cambric around a stick of suitable cross section. These tubes are made long enough to project at least ¼ inch at each end. Since the slots are thus entirely closed, the winding must be threaded through, but this presents no great difficulty, as less than twenty feet of wire are required for each coil. The uppermost coil shown in Fig. 1 has just been started. A temporary block of wood is required at each end to bend the wires around, and, to keep the wire in layers and make a workmanlike job of it, it is desirable to begin by first filling up the slots with temporary sticks of fiber, or wood, which are removed in measure as the winding progresses. The middle coil in the photograph is completely wound, while the lower one has been finished by a covering of tape. An alternative finish, shown in Fig. 4, consists of a wrapping of fine twine, afterward shellaced.

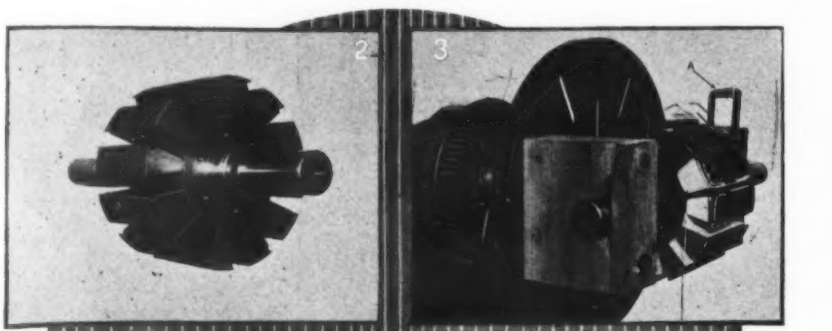


Fig. 1.—Rewinding the stator. Fig. 2.—New rotor core on shaft. Fig. 3.—Winding the rotor. Fig. 4.—Generator complete.

A good idea of the kind of core required for the new rotor is given by the view in Fig. 2. It consists of a solid piece of low grade (0.15 per cent carbon) steel, which is soft and easily machined. This, in most cases, may be mounted on the old shaft. Turning such a core in a small lathe presents no difficulty, but the operation of milling the twelve slots is best done at a properly equipped machine shop.

In designing a rotor to fit any given stator two critical points must be kept in mind. First, the rotor must be 0.04 inch less in diameter than the bore of the stator, leaving an air gap of 0.02 inch all around. Second, a width of slot must be chosen that will remove about 35 per cent from the periphery of the rotor, thus leaving about 65 per cent of the circumference occupied by the polar projections, each of which will then match up with two stator teeth. The parts shown in the illustrations have the following dimensions: Stator core, 4¾-inch bore, 2¾ inches long; rotor core, 4.71 inches diameter, 2¾ inches long; slots, 7/16 inch wide, 1 inch deep. It will be noticed in Fig. 2 that a small groove is milled in each side of every slot near the top. These notches are for the insertion of metal strips to retain the windings in place. Provision must also be made on the rotor for mounting an insulated brass ring at each end, to serve as collector rings for the exciting current. See Fig. 4. These are best supported and insulated by hubs of condensite, bakelite, alberine, stone or other non-warping material. Fiber is not to be recommended, because of its liability to warp.

The selection of the proper winding for the rotor depends on the voltage available for its excitation. If the generator is to be driven by a direct current motor the rotor may be excited from the same source of current supply, but if any other kind of power is used there will also be needed a small dynamo of about 150 watts output, to supply the rotor current. In the latter case it is recommended that the voltage used be not higher than 60 nor lower than 30. Higher voltages require so many turns of fine wire on the rotor that the winding becomes tedious, while lower voltages introduce problems in carrying the proportionately heavier currents. The machine shown in the illustrations is wound for 60 volts. On each pole of the rotor there are 138 turns of No. 22 single cotton covered wire, put on in six layers of 23 turns each. For 30 volts the winding would have been much easier, since there would have been required only 68 turns per pole of No. 19 single cotton covered wire, put on in 4 layers of 17 turns each.

The winding of the rotor was greatly facilitated by bolting the latter to the faceplate of a small lathe head, which in turn was mounted on a wood box as shown in Fig. 3, thus permitting the rotor to be turned end over end as the wire was put on. Thorough insulation of the rotor core was first secured by shellacing troughs of tough paper in the slots, by folding it over the ends of the poles and by reinforcing the latter with pieces of cardboard as shown. To hold the outer turns of wire from slipping off the pole, two temporary U-shaped pieces of sheet brass were made to fit in the grooves at the top. One of them is shown in place on the pole being wound, while the other has been removed for the moment and is standing on the block at *A*.

After each slot was filled, the winding was given a coat of shellac, a protecting strip of insulation was laid on top of the wires, and, lastly, a strip of 1/32 inch thick phosphor bronze was inserted in the grooves, thus holding the slotfull permanently in place. The coils are, of course, connected in series with alternate polarities all the way around, and the terminal leads are soldered to the two collector rings. As this arrangement brings the two end coils together in the same slot, the precaution was taken of inserting a thin slip of mica between these two coils to prevent possible puncture of insulation by the inductive "kick" when the field current is broken.

Since the rotor runs at moderately high speed it is essential that it be carefully balanced mechanically. This is easily accomplished by supporting the rotor shaft on two level parallel bars, upon which it will roll until it finally comes to rest with the lighter side up. Additional strips of the phosphor bronze may then be inserted in the proper slot grooves until the rotor will lie indifferently in any position.

All parts of the machine have now been described with the exception of the brush holders. In Fig. 4 one of these can be seen attached to the front shield in such a position that the brush bears on the collector ring when the parts are assembled. Brush holders of the fan motor type, consisting of a piece of brass tubing in which a carbon brush is pressed forward by a slender helical spring, are convenient for the purpose. For currents up to six amperes a carbon brush having a cross section of ¼ inch by ⅜ inch is ample.

The efficiency of the generator built by the author is about 70 per cent, so that about one horse-power is required to drive the machine when delivering one half kilowatt and two horse-power when delivering one kilowatt. The output is, of course, controlled by a rheostat in the rotor circuit, and no more exciting current is used than just enough to get the desired results. When forcing the output of the generator to the limit there is danger of burning out the rotor winding, so that the aerial switch should be arranged to cut off current from the rotor while messages are being received.

Test results of the machine on a load adjusted to about 80 per cent power factor were as follows:

Amperes in rotor	1.25	1.84	2.33	2.77
Output in watts	250.	500.	750.	1,000.
Output in volts	73.	106.	132.	154.
Output in amperes....	4.1	5.9	7.2	8.2
Open circuit volts....	152.	207.	236.	250.
Short circuit amperes.	6.6	9.7	12.2	14.5

In a Steam Driven Shaft a recurring variation of speed of 6 per cent has been shown by a tachograph. In a similar electrically driven shaft the variation was but 0.5 per cent.

Facts About Thunderstorms

Their Origin Formation and Structure

[Few subjects have been so much befogged by incompetent writers as that of the thunderstorm and its phenomena. Moreover, much that has been written on this subject by persons who were for their time excellent authorities has been rendered obsolete by the general progress of physics. Only a few years ago a rational explanation of lightning was impossible, because nothing was then known about the ionization of the atmosphere. At this moment it is impossible to cite any work on meteorology or physics, or any general work of reference, in which all the ordinary phenomena of the thunderstorm are described and explained in a manner satisfactory to the modern physicist. We, therefore, feel that a recent memoir on thunderstorms, published by Prof. W. J. Humphreys in the *Monthly Weather Review*, which presents a nearly complete account of this subject in the light of the very latest investigations, is entitled to the rather long abstract which we give below. Prof. Humphreys's paper not only reviews the latest discoveries of others, but also includes some highly ingenious contributions of his own; e. g., the suggested explanations of rocket lightning, ball lightning, and the rain-gush. This writer also gives what appears to be the first plausible account of the air circulation in a thunderstorm.—EDITOR.]

Origin of Thunderstorm Electricity.—This long-mooted question appears to have been settled by Dr. G. C. Simpson of the Indian Meteorological Department, whose results, obtained about four years ago at Simla, have been confirmed by observations in other parts of the world. Simpson's investigations on Indian rainfall showed that the electricity brought down by rain was sometimes positive and sometimes negative, while the total quantity of positive electricity brought down was 3.2 times as great as the total quantity of negative electricity. Various other definite numerical results were obtained in regard to the electrical charge of both rain and snow, in connection with duration of fall, atmospheric potential gradient, and other circumstances.

These facts were evidently connected with the separation of positive from negative electricity which gives the immense potential gradients occurring in a thunderstorm, and the next step was to discover the agency producing such separation. Freezing and thawing, air friction, and other things that have sometimes been invoked to explain thunderstorm electricity were tried without giving adequate results. Finally Simpson allowed drops of distilled water to fall through a vertical blast of air of sufficient strength to produce spray, and the following significant facts were ascertained:

1. The breaking of drops of water is accompanied by the production of both positive and negative ions.

2. Three times as many negative ions as positive are released.

In other words, a preponderance of positively charged water drops is produced by this process. Now, a thunderstorm is characterized by strong upward currents of air, and experimental evidence, which need not be recorded here, shows that these are ample to account for the breaking up of all rain-drops which would otherwise fall through them. Hence, at the top of the uprushing air current of the storm—i. e., within the thundercloud—a rapid electrical separation goes on, the first result of which is positively charged rain drops and free negative ions. The charges of the former are, moreover, continually increased by the successive division and coalescence of drops. These positively charged drops fall to the earth whenever the air current becomes weak enough to permit their passage. The negative ions are carried up into the higher part of the cloud, where they unite with the cloud particles and facilitate their coalescence into negatively charged drops. These ultimately fall in the gentler rain of the storm. Thus the same process that produces the giant cumulus cloud of the thunderstorm—i. e., a violent uprushing current of moist air—also gives the separation of electricity required to produce lightning.

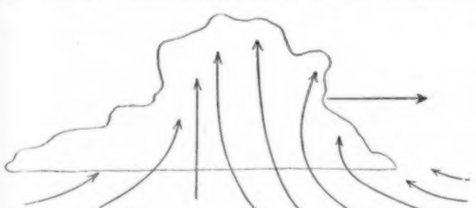


Fig. 1.—Air currents in the thundercloud, when forming.

Types of Thunderstorm.—Any meteorological situation that includes a stratum of warm air lying beneath a stratum of cold air is likely to give rise to a thunderstorm if the temperature contrast be strong enough. Such a situation is unstable, and leads to the violent convectional process which is the essential feature of a thunderstorm. It may arise from intense local heating of the earth's surface (local or heat thunderstorms); or from the overrunning of one layer of air by another at a temperature low enough to induce convection. Thunderstorms may probably also result from the underrunning and consequent uplift of a saturated layer of air by a denser layer. The second and third situations arise in connection with the larger cyclonic movements of the atmosphere. Prof. Humphreys classifies the non-local types of thunderstorms as cyclonic, tornadic, anticyclonic, and border thunderstorms, according to their locations with respect to cyclonic and anticyclonic systems. The tornadic storms are those formed in the barometric valley between the branches of V-shaped isobars, which is also the region where tornadoes develop. A line or row of such thunderstorms, extending radially from a cyclonic center, constitute the well-known "line-squall." On land thunderstorms occur most frequently in the early afternoon and in summer; at sea they are most frequent at night and in winter; in consequence of well-known thermal contrasts between land and water surfaces, respectively, and the air above them. As to fluctuations of longer period, thunderstorms are more frequent in warm and wet years than in cold and dry ones. The ultimate controlling factor is temperature, and this appears to vary in consonance with the sunspot period, but with modifications due to an occasional excess of volcanic dust in the atmosphere.

The Structure of a Thunderstorm.—A thunderstorm is not the beautifully simple vortex with horizontal axis that has so often been described and pictured in books. The actual air circulation in the storm is shown in the accompanying diagrams. First, we have (Fig. 1) air flowing in from all sides, rising, cooling by expansion, and building up the typical thundercloud. At the same time the whole system is moving forward, under the control of the prevailing cyclonic circulation. Ultimately, as a result of strong convection, rain is formed at a considerable altitude, where the air is quite cold—in fact, so cold that hail is often formed. This cold rain, or a combination of rain and hail, as it falls to earth chills the air all the way down to the ground, partly as a result of its initial low temperature, and partly because of the evaporation that takes place during its fall. This cold column of air is correspondingly dense, and becomes a strong downward current. The frictional drag of the falling rain is an additional factor in giving it this downward movement. Fig. 2 shows this current at *D*, plunging down and at the same time carried forward by the general movement of the storm, underrunning and buoying up the warm adjacent air in front. This current is the typical thundersquall, which rushes forward from an approaching thunderstorm, agreeably cooling the air.

It should be especially noticed that the descending current does not immediately curve upward and return to the summit of the storm, nor does the air ascending in front of the storm immediately descend as a cold return-current. *The circulation does not occur in a closed circuit.*

Between the uprising sheet of warm air and the adjacent descending sheet of cold air horizontal vortices are, indeed, formed, in which the two currents are more or less mixed. These undoubtedly occur at various levels, but they only become visible at a point near the front lower edge of the main thundercloud, where the rising air has so nearly reached its dew-point that the somewhat lower temperature produced by the admixture of the descending cold air is sufficient to produce a light fog-like condensation. This constitutes the squall cloud, or roll scud.

The march of the meteorological elements at the earth's surface accompanying the passage of the storm is shown in Fig. 3. Here we see (1) an abrupt fall of temperature, due to the rain-cooled descending current; (2) a sharp rise of barometric pressure, which Humphreys believes to be the joint effect of *a* a decrease of horizontal flow, due to surface friction, *b* vertical wind pressure, due to descending air; *c* lower temperature; and *d* decrease in absolute humidity; (3) a violent gust of wind (the thundersquall, above explained); and (4) the initial heavy rain of the storm.

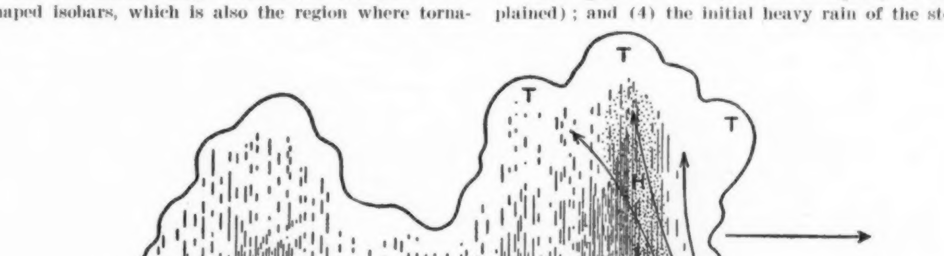


Fig. 2.—Ideal cross section of a typical thunderstorm.

A, ascending air; *D*, descending air; *C*, storm collar (strumkarfen); *S*, roll scud; *D'*, wind gust; *H*, hail; *T*, thunderheads; *R*, primary rain; *R'*, secondary rain.

The Rain Gush.—This name is given to a sudden acceleration in rainfall immediately following a heavy clap of thunder. Its reality has often been questioned, but it appears to be susceptible of a simple explanation: Excessive condensation anywhere in the thundercloud will lead to a local excess of electrification and electrical discharge, since the latter processes depend upon the presence and abundance of water-drops, as shown by Simpson's experiments. Hence excessive condensation or rain formation really precedes the thunderclap, but as sound travels faster than rain falls, we hear the thunder before the rain gush reaches us.

Hail.—This consists of roughly concentric layers of snow and ice, and can only be formed in the upper part of the thundercloud, where both snowflakes and undercooled water-drops are present. The nucleus of the hailstone, having formed in this cold region, gets into one of the weaker updrafts of the storm, and falls to

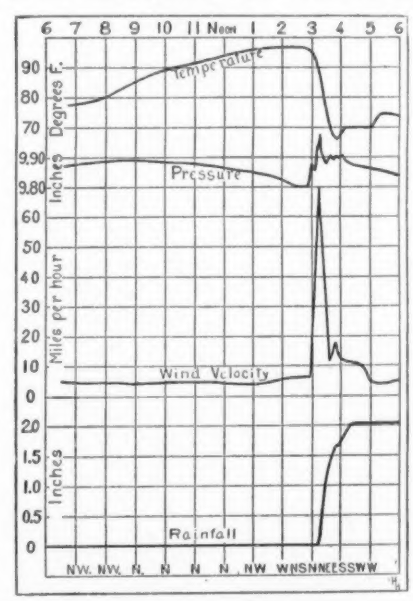


Fig. 3.—Course of meteorological elements on a thunderstorm day, at Washington, D. C. (July 30th, 1913.)

the level of liquid drops, where its own low temperature enables it to gather a coating of ice. Presently a more violent upward puff carries it again aloft, and it acquires a coating of snow. This process may be repeated several times, until the hailstone is too heavy to be supported by ascending currents, and falls to earth.

Lightning.—The moving-camera photographs of Walter, Larsen, and others have greatly helped to elucidate the mechanism of the lightning flash. (See SCIENTIFIC AMERICAN, June 29th, 1912, p. 586, and March 22nd, 1913, p. 108). These photographs show how often the flash builds itself up gradually, and consists of several successive discharges along an identical path. The discharge differs from that of an electrical machine, in one important respect—the distribution of the charge. In the case of the machine this exists almost wholly on the surface of the apparatus, while in that of lightning it is irregularly distributed throughout the cloud. In both cases, however, the air must be ionized before the discharge can take place freely, and this condition seems, at times at least, to establish itself gradually. The tremendous differences of voltages involved in the production of lightning have always been a stumbling-block to its explanation. Prof. Humphreys has advanced, tentatively, an explanation that obviates the necessity of assuming these great voltage differences; according to his view, the spark, once started, ionizes the air and makes its own conductor as it goes. A roughly analogous phenomenon can be produced on a photographic plate by bringing in contact with the film, some distance apart, two conducting points attached to the opposite poles of an influence machine. Brush discharges develop about each point, but the glow at the negative pole detaches itself and slowly meanders across the plate toward the positive point. This explanation—which we unfortunately have not space to give in detail—furnishes a possible clue to the origin of rocket lightning (a flash progressing slowly across the sky, like a sky-rocket) and ball lightning. These would not, according to the hypothesis above referred to, differ in kind from ordinary lightning, but merely in the amounts of ionization, quantities of available electricity, and steepness of potential gradients.

Is lightning unidirectional or oscillatory? Many writers have dogmatically pronounced it to be oscillatory (and the design of lightning-rods has been influenced by this belief), but Prof. Humphreys gives the following reasons for holding the contrary opinion:

1. Lightning operates telegraph instruments. If the discharges were alternating it would not do so.

2. At times it reverses the polarity of dynamos. This requires a direct and not a high-frequency alternating discharge.

3. The oscillograph (as shown by some recent observations of L. O. De Blois) shows each surge or pulsation, as well as the whole flash, to be unidirectional.

4. The relative values of the ohmic resistance, the self-induction, and the capacity, in the case of a lightning discharge, appear, usually, if not always, to be such as to forbid the possibility of oscillations.

Problems of Geographic Influence*

Its Relations to Sociology, Biology, and Climatology

SOCIOLOGY is a science which equally with geography has aroused skepticism concerning its right to be called a science. Be that as it may, its devotees occupy ground which stretches into historical territory, on the one hand, and geographical and anthropological on the other. This is conceded by Small.

"The comprehensive science has the task of organizing details which may already have been studied separately by several varieties of scholars."[1]

The same author sets forth the influence of nature with an emphasis which if used by the geographer might call down a charge of excessive claim.

"Nature sets our tasks, and doles out our wages, and prescribes our working hours and tells us when and how much we may play or learn or fight or pray. Life is an affair of adjusting ourselves to material, matter-of-fact, inexorable nature."[2]

Small does not think we yet have an adequate story of the operation of cosmic laws in determining the course of human development.

Mr. E. C. Hayes, in a paper in the *American Journal of Sociology*,[3] discusses the relation of geography to sociology and the definition and scope of geography. He seems disposed to think that stating the effects of geographic conditions on social phenomena will be an integral part of sociology, but thinks "it will still remain true that no science but geography describes the regions of the earth by bringing together into one description all the various facts separately studied by the different sciences."[4]

It is fair to say that only the geographer can know the physical conditions in a broad and deep way. It is just as fair to expect the sociologist to be superior in the strictly human field. But neither can dismiss the other, nor prescribe a legitimate boundary line of research. And there is always the possibility of a genius equally at home in both fields, scorning all petty frontiers of our so-called sciences, fusing and recreating the data and conclusions of lesser men, and recording for all time those large generalizations of which we dream and for which we strive.

After all that can be said on the relations of geography to other subjects, I am content to come back to a confessedly general, but safe and truthful word by James Bryce:

"Geography is the point of contact between the sciences of nature taken all together and the branches of inquiry which deal with man and his institutions."

Climatology is beginning to be appreciated in relation to other fields of physical geography. We begin to value and to express in text-books the relation of the atmosphere to the origin of land surfaces, glaciers, aridity, and the waves and currents of the sea. We see its functions also in relation to the mineral contents of the earth, and in relation to the origin and use of soil.

Even more pronounced is the growth of ideas in relating the atmosphere to fauna and flora, to plant and animal types and societies, to bacteria, and to forests, steppes and deserts. Involved in all this relation to the inorganic and organic world is an immense indirect influence on man.

There is also direct influence on man, through temperature, varying constitution, variations of pressure, moisture content, movements, optical effects, and sound waves. And we cannot stop short of psychical, social, and economic phases of influence, all tangled in difficult fashion.

Geography has a considerable body of good knowledge of climate in relation to modes of living in typical parts of the world. We know that the Eskimo is carnivorous, the tropical savage vegetarian, and that the denizen of temperate latitudes brings both foods to his table. We know the climatic results in clothing and shelter, in nomadic and pastoral, agricultural and static life, and among hunters of the forest. These are all important, but more or less indirect climatic effects, so well set forth by Herbertson in "Man and His Work."

But what of direct effects of climate? I hesitate to use the word direct of such activity. Such is our ignorance of the precise efficiency of these forces, that apparent direct agents may turn out to be mediate, after all.

How much exact knowledge have we in the field of coloration? Grant that this is mainly a physiological problem, so far as man is concerned, will it ever be solved, and the results broadly stated except in collaboration with geography?

"Color almost certainly developed in strict relation to climate. Right away in the back ages we must place the race-making epoch, when the chief bodily differences, including differences in color, arose among men."

This is from Marett, and he adds that natural selection had a clear field with the body before mind became the chief factor in survival.

Brinton says that climate and food supply are the main causes of the fixation of ethnic traits. He adds that temperature, humidity and other factors bear directly on the relative activity of lungs, heart, liver, and skin. This seems to come near to the core of things, but no precision is reached, and I suppose cannot be in the present state of knowledge. Ratzel was not wrong in citing the negro's dark skin as illustration of the fact that the search for causes goes after hard and deep-rooted things.

The study of the races of Europe teems with conjectures about blonde and brunette, but the physiological basis is wanting. We should like to know whether the Mediterranean longhead is a darkened Teuton, or whether the Teuton is a bleached African. Here is joint work for physiologist, anthropologist, and geographer.

This field, therefore, is almost unworked. I hesitate to say that the door for research is wide open, but one would hesitate even more to believe that the problem cannot be solved.

Suppose now we leave these primitive and racial puzzles and come down to possible effects of climate that can be seen and registered in a few generations, if there be such effects. Here is the question of acclimatization and tropical disease, in short, of the white man's burden.

Here again Ward proceeds with instructive caution. It is a complex subject, he says, conclusions are contradictory, curves may be made to show anything. There are many weather elements and there are many other factors, such as sanitation, foods, water, habits, altitude, soil, race, traffic and other controls. Micro-organisms intervene to make climate largely an indirect influence.[5]

Thus we have a group of problems for the medical observer, but either in him or with him must the geographer share the task whose successful accomplishment affects the destinies of every colonial empire and the ultimate place of the white race. Altogether in this whole field, a field of high practical importance, there has been much sincere effort, but no great harvest.

Let us look at the field of biogeography in relation to man. The distribution of plants and animals as forming large elements in environment cannot fail to involve man and to uncover many interesting relationships. This study is now in a hopeful state of vitality and progress. Our own association has a good number of workers in this field.

A wealth of pertinent facts awaits discovery and co-ordination as regard the coincident distribution of man with plants and animals. Payne uses this as a basal principle, showing the migration and presence of organic forms in casual relation to man. A few suggestive illustrations may be given. Kirchoff in his "Man and Earth"[6] co-ordinates the Mediterranean spread of the Phœnicians with the occurrence of the dye-yielding mollusc. Dr. C. Hart Merriam once surprised the writer by saying that the beaver was the most important fact in early American history. The more one considers this the less one is disposed to consider it as an outburst of a biologist's enthusiasm.

In Hansa days tens of thousands of people dwelt in the Peninsula of Schonen, in the towns of Falsterbo and Skänor, at the most southwestern tip of Sweden. To-day an old church, a few cottages and a summer hotel make up Falsterbo, while Skänor is a sleepy village of a few hundred people. Why should this throbbing Baltic market of centuries ago have suddenly declined to insignificant shore villages? Because the herring migrated to other waters. A new harbor has been built at Skänor and it will be seen whether modern conditions can restore the prosperity with the runaway fish destroyed.

Dr. Scharfetter in a work on the distribution of plants and man sets the Roman boundary in Germany at the edge of the Franconian forest and cites the fact that the Arabs went wherever the date palm would grow.[7] The practical biologist, such as the argicultural explorer, turns the problem around, shows how to control the distribution of lower life and thus to modify the distribution of man.

The climatologist asks for definite climatic effects on man. The ethnologist or sociologist finds traits in man which might have a climatic origin. The geographer wants all that all types of specialists can give him, both in the physical and psychical spheres. Thus we may approach from the point of view of causes or of results and follow down or up the stream of effects.

Let us turn to certain groups of phenomena in the realm of effects or results. The most important and surely the most baffling problems here are in the psychic field. Here the geographer will be peculiarly dependent on workers in sister sciences and the gap may be hard to bridge. If we can offer a stimulus which shall lead these kinds of scholars to struggle up the stream of causality, it may be safer than for us to drift down through rapids and among rocks. But the work ought to be done, and the geographer can at least show its worth and encourage the doing of it.

In this research we are not to think that the earth was all powerful with early man, but is helpless to-day. Color or other race features may have been fixed, but this is not all. If there is something in man that is found in every man, wherever he is, he is not thereby released from the pressure of environment. Psychic

* Abstracts from the address of Prof. Albert P. Brigham, president of the Association of American Geographers, at the eleventh annual meeting at Chicago.

[1] A. W. Small, "General Sociology," 7.

[2] *Ibid.*, 408.

[3] Vol. xiv, 371-407.

[4] *Ibid.*, 400.

[5] "Climate," 180 et seq.

[6] Trans. of "Mensch und Erde," 30-31.

[7] Paper is noticed, *Scot. Geog. Mag.*, vol. xxvii, 39-41.

reaction on nature does not destroy nature's efficiency, but in a degree directs, refines and uses it. When Prof. Lester F. Ward says that "the environment transforms the animal, while man transforms the environment,"[8] he utters but a partial truth. Perhaps he was attracted by rhetorical form, for in a later passage he recovers himself, recognizing the psychic effects of environment, for, "Courage, love of liberty, industry and thrift, ingenuity and intelligence, are all developed by contact with restraining influences adapted to stimulating them and not so severe as to check their growth."[9]

We leave this topic with the single suggestion that in the psychic field, a useful and difficult piece of research is open to the student of comparative religions, who is at the same time interested in anthropogeographic problems and has the needed geographic training. How far the essential content of religious aspiration and thought, as well as the ritual of worship, has been influenced by environment, has, I think, never been shown in any full synthetic way. It is a task of no common difficulty, not to be lightly undertaken, but worth the doing.

Another field of effects, much more accessible to the pure geographer, is the distribution of population studied in the casual way. Enough practice in statistical method for this inquiry can be readily acquired and the results should be most fruitful. Jefferson's recent papers have been suggestive in this field of research, which involves in intimate combinations, physical, economic, racial and social conditions. Akin to this study is the classification of towns and cities, developing the principles of origin, growth and differentiation, as in a recent valuable paper of Chisholm. The city as a geographic organism may be freely taken as an inexhaustible theme.

Another great sphere lies in regional studies, such as States, physiographic units, and countries. The number of such studies, maturely developed, now available may perhaps be counted on the fingers of one's hands. The aim should be not alone directed upon the more obvious matters of route and industry, but also upon deep and underlying principles. What rich and alluring subjects for the intensive student would the State of Pennsylvania offer, of Kentucky, Minnesota, or California! Who will develop for us our coastal plain or piedmont, treating town sites, roads, soils, crops, industries, racial composition and social status? Who will do a like work for the great Appalachian Valley, that magnificent and little understood unit of our east—its trails and roads, its agriculture, towns, migrations and historical significance in colonial and current life? There is room for more such studies as those of Whitbeck upon glacial and non-glacial Wisconsin and of von Engeln on the effects of glaciation upon agriculture.[10] The latter, indeed, is not regional except as it naturally deals largely with principles as illustrated in our own country.

Will Mr. Mackinder, or someone else, take up Great Britain, omitting the purely descriptive, as he could not in Britain and British seas properly do, and discuss more fully questions of geographic influence as regards agricultural distribution, the localization of industries, the distribution of population in general, and the effect of various factors such as insularity, climate and world position in the development of British character, British political unity, and British social conditions.

Or in the United States, there are racial compositions, new physical environments, offering new social and economic conditions to population groups as seen in comparison with conditions in the parent lands of Europe. Finally, there are innumerable beckoning fields, of a small and local sort, out of whose diligent study general principles will rise and become established.

Our goal is broad generalization. But the formulation of general laws is difficult and the results insecure until we have a body of concrete and detailed observations.

Detailed investigation of single problems, in small and seemingly unimportant fields, must for a long time prepare the way for the formulation of richer and more fundamental conclusions and general principles than we have yet been able to achieve. We should not wait for someone to state or demonstrate these laws. This is yet, even for a genius, impossible. We must contribute in partial, microscopic, sometimes unconscious ways to the emergence of such laws.

Prof. Adams, speaking of the available and most useful tasks of the historian, has a word which is equally good for us:

"To furnish materials, to do preliminary work, is to make a better contribution to the final science than to yield to the beguiling allurements of speculation, to endeavor to discover in the present state of our knowledge the fundamental forces that control society, or to formulate the general laws of their action."[11]

Not only is this a model principle, but it emphasizes the value of our goal, for the real philosophy of history will not be written until geographic factors have had broader and deeper recognition. Here I do not speak as a geographic enthusiast, nor in denial of the supremacy of the human spirit.

[8] L. F. Ward, "Pure Sociology," 16.

[9] *Ibid.*, 58.

[10] O. D. von Engeln, "Effects of Continental Glaciation on Agriculture," *Bull. Am. Geog. Soc.*, xlvi, 241-64, 336-55.

[11] George B. Adams, *Am. Hist. Rev.*, xiv, 236.

Use of Electricty in Ships

The use of electrical power for the operation of auxiliaries in all types of ships did not make so much headway as might have been expected for a long period after its possibilities were recognized. It was not, in fact, until the Mauretania and the Lusitania were constructed that the many advantages of electrically-operated accessory plant over steam-driven sets were actually shown in practice. Since that time, however, much progress has been made, and during the next ten or fifteen years the development should be such as will have a very distinct bearing upon the electrical trade in this country.

It would seem, too, that with the gradually increasing employment of the internal combustion engine for ship propulsion, the use of electrically-driven auxiliaries will become more and more common, for evidently there is a certain anomaly in employing oil fuel for propulsion and yet installing boilers to raise the steam necessary for the relatively few auxiliaries on board the ship. This arrangement has frequently been adopted, and it must indeed be admitted that probably there are more motor ships with steam-driven auxiliaries than with purely electrically-operated sets. There are indications, however, that this state of affairs will not continue very long, for the results which have been attained by some of the most important motor ships in which electrically-operated winches, capstans, pumps, steering gear, etc., are employed, have been very satisfactory from the points of view both of reliability and of economy in operation.

Reliability and Cost.

The main objections that have been raised against the use of electricity for the purpose are that the electrical plant was not sufficiently reliable for marine work, and secondly, that it was more expensive to maintain and operate. During the period that electrically-driven auxiliaries have been in use these objections have been more or less disproved, although possibly the cost of operation of electrically-driven sets when the dynamos are coupled to steam engines is, in certain cases, greater than when the auxiliaries themselves are driven by small steam engines. When, however, the main dynamos in the engine-room are coupled direct to oil engines of the Diesel type using heavy and cheap fuel, the conditions are reversed, and the actual fuel costs are very much less than with steam-driven plants. This fact has been borne out by careful examination of the relative costs in the two instances by well-known shipping firms, and combined with the general reliability of the electrical plant it has done much to influence shipowners and marine engineers in favor of using electricity wherever possible in their newer vessels. How greatly this view has gained ground may be instanced by mentioning that when some fifteen or sixteen orders were placed for motor vessels a short time ago, in every one of them electrically operated auxiliaries were specified and steam was entirely dispensed with.

The Question of Voltage.

Many interesting problems face the electrical engineer in connection with the installation of an electrical plant on board a ship. Most of these have now been carefully worked out, and the experience gained in all directions during the past seven or eight years has been sufficient to indicate what variations from ordinary practice are desirable at sea. In the early days it was thought that a low voltage was more suitable for ship work than a higher one, because there was less danger, and also because longer life was given to the lamps owing to the stronger filament of the lower voltage bulb. Consequently a voltage of 50 was not at all unusual, and 100 was for some time the maximum, this latter pressure being adopted in the Mauretania.

But the employment of such low voltages was distinctly uneconomical and caused excessive cost of installation owing to the large cables necessary and the greater weight of the motors and other appliances. Recently it has become more usual to employ higher voltage—up to about 220—this step having been rendered possible owing to the greater confidence that has been gained with electrical installations as a whole and also to the greater strength of the lamps now manufactured. Originally it was not customary to use metallic filament lamps at all on ships owing to the large number of breakages and the high cost of renewal, but this more economical type of lamp is quite common at the present time.

Generation of Power.

Even on steamships it is not at all unusual to provide for the electricity supply by oil-driven generating sets, owing to their general convenience and economy, but when this is not done it is almost universal to install what is usually called an emergency set well above the water line, so that in the event of the engine room becoming flooded, the emergency set can still continue to run and so provide light for the vessel and also the necessary power for the wireless telegraphy set. This statement applies, of course, mainly to passenger vessels and not to the ordinary cargo-carrying craft. These emergency sets are generally driven by Diesel engines, although it is not unusual for paraffin motors to be employed, or even semi-Diesel engines. On battleships since the first Dreadnought, Diesel engine generators have frequently been installed in the engine room for the electrical power throughout the ship.

Electrical Driving of Auxiliaries.

The motor ship offers the best possible opportunity for the most general application of electrical power for auxiliary drive, and a good instance of the successful manner in which it can be carried out is the recently built motor-ship Mississippi, in which electricity is employed for absolutely all auxilary purposes, no steam whatever being provided. Even the heating is carried out electrically, as well as the cooking, and the operation of the steering gear and all the deck and engine-room auxiliaries. In this ship, in which the propelling machinery consists of two 1,800 horse-power oil engines, there are installed two 200 kilowatt Diesel driven dynamos as well as an 80 horse-power semi-Diesel engine-driven generating set, and another 75 kilowatt dynamo coupled direct to a Diesel engine. This large amount of auxiliary power is required since the vessel is employed in the cargo carrying trade and has fourteen winches on deck besides an anchor capstan. In the engine room the various bilge and circulating water pumps are electrically operated as well as the sanitary and ballast pumps, together with the various oil pumps, the refrigerating machinery and the air compressors for the main and auxiliary engines.

Electrically operated steering gear was at first looked at askance by shipowners and marine engineers, who were doubtful whether it could compete in reliability with the old steam-driven gear. Steering gear actuated direct by electric motors is still seldom employed, the most usual arrangement being the adoption of the electric-hydraulic principle, such as is used in the Hele-Shaw gear. Several firms have, however, recently taken up the purely electrically operated type; and the results attained are said to have been extremely satisfactory. In any case, whether the electric-hydraulic or the purely electrical principle is employed, no steam is necessary for the work.—*Engineering Supplement London Times.*

Elements With Several Atomic Weights

Scientists of the present generation consider matter to be made up of small particles called molecules. These molecules are themselves composed of smaller bodies to which the name "atom" has been given. The atom has been defined as the smallest particle of an element that enters into combination with other atoms to form molecules.

Now just as the various elementary substances have different weights, so must the atoms of the individual elements have different weights, and it was natural that scientists should seek out a basis upon which to compare the relative weights of atoms. The actual weights of the atoms are of course too small for convenient comparison, and as a result, the atom of the lightest known element, hydrogen, was arbitrarily chosen as the standard unit, and all the others were expressed in terms of this unit. The atomic weight of an element might, therefore, be defined as the relative weight of the atom compared to the weight of the atom of hydrogen as 1.

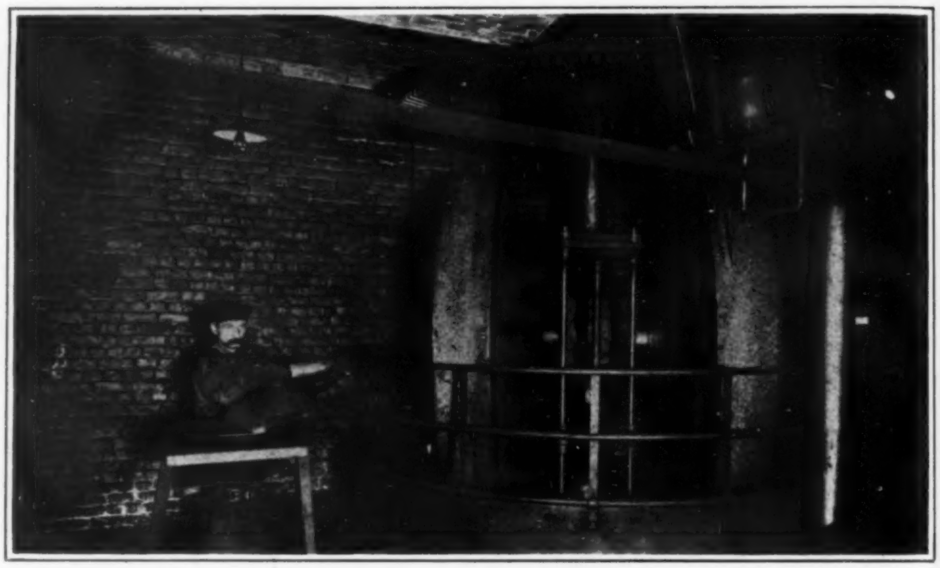
It was formerly supposed that each element had one, and only one, atomic weight, but it has been shown by recent investigation that lead from radio-active substances has a different atomic weight from that of the ordinary variety. Strange to relate, however, these different kinds of lead, if different in kind they are, have precisely the same chemical properties. That is, although the element itself may differ in atomic weight according to its source, the salts of the different varieties are identical. It has been suggested that elements, which have the same chemical properties but different atomic weights, such as lead has, should be called isotopes.

Many scientists have long been waiting to be shown that all the eighty odd elements are composed of one, or at least a few simple substances. The new discovery may be a step in this direction.—*E. B. S. in Science Conspectus.*

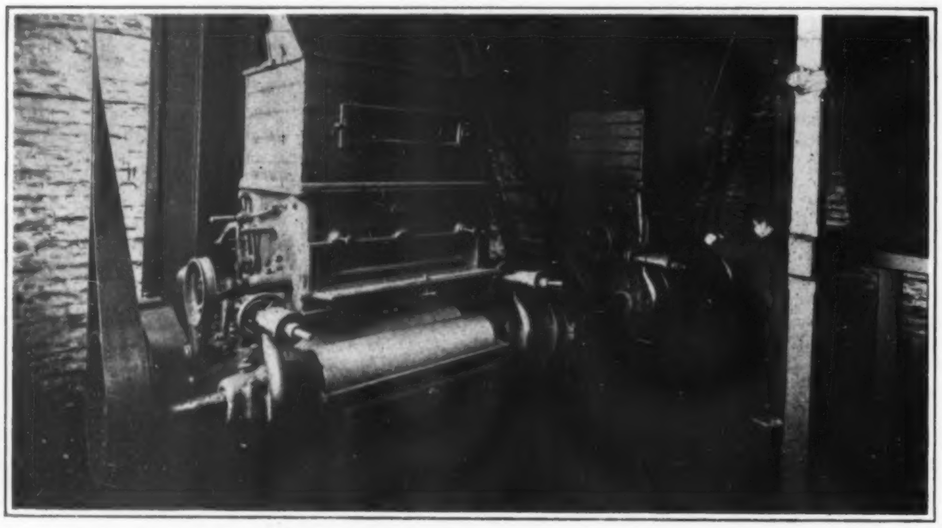
Digging roots with a plow.

Unloading the roots at the factory.

The root cutting machines.



Grinding chicory powder for coating.



Roller mill for crushing the roasted material.

Packing the finished product.

Roasting the chicory.

Bagging the dried chicory.

VARIOUS PROCESSES IN THE MANUFACTURE OF CHICORY

The Manufacture of Chicory

A Franco-Belgian Industry Stopped by the War

By Jacques Boyer

THE war has paralyzed the industrial activity in Belgium and northern France. A great number of factories were sacked, destroyed or removed by the Kaiser's hordes. The copper apparatus of the sugar factories and refineries of the Aisne, of Pas-de-Calais or of the Ardennes such as vats, stills, rectifying columns of the breweries of the north or the alcohol distilleries of the Somme were sent to the arms factories beyond the Rhine in order to be converted into cartridges, shells or other murderous projectiles. The coal taken from the mines of Charleroi, Bethune, Lens or Bruay is going to join in Germany the wool taken from Tourcoing and Roubaix. But the manufacture of chicory is one of the industries which has suffered most from the present struggle owing to the fact that the fields where this plant was cultivated, as well as the factories in which its roots was converted into a coffee substitute, are located on Belgian territory or in the French departments now invaded. We shall, therefore, devote a short study to this merchandise which has almost entirely disappeared from the market.

yield is less than that of the Magdeburg variety; this is counterbalanced by the fact that it dries more readily and that it yields a highly appreciated manufactured product. Moreover, on malting the Magdeburg variety undergoes a more considerable reduction of weight, its husks maintaining a whitish tint even after roasting; for this reason its roots are sold at a price 10 per cent lower than those of the Palingkop variety. In spite of this, it is cultivated by the majority of the French growers, whereas in Germany the variety encountered most frequently is the Brunswick chicory or sugar-beet chicory having deeply serrated and curled leaves approaching the Tete d'Anguille variety. It is suitable for less deep soils or soils with mediocre sub-soil.

Whichever variety is selected, the seed is generally sown in lines, about 3 to 5 kilogrammes per hectar, by means of a special sowing machine, and is covered by harrowing and completely buried by passing a roller over the field.

Eight or ten days after sowing, the seed sprouts, and as soon as the cotyledonous leaves appear the weeds are

which conveys them to an upper floor. There an inclined chute delivers them to two root-cutters from which the roots, cut into small pieces, are conveyed to the malt-kilns. These special driers have either one, two or three compartments. In the latter case the chicory is first spread over the perforated floor of the upper compartment of the malt-kiln, where it remains for about 12 hours, after which it is pushed down through trapdoors to the second compartment where it remains for the same length of time, after which it is dropped by a similar arrangement to the first or lowest compartment where the drying process is completed and whence, after cooling, it is collected in bags.

Then the roasted chicory undergoes various operations. These agricultural factories generally possess from 6 to 18 kilns. Each kiln will dry 3,000 to 3,500 kilos of green roots daily. Thus in order to supply the cutting plant of Alphonse Leroux of Fretin (Nord) which comprises three batteries of 6 kilns each, normally fired during three months, 200 hectars of chicory plants are required, each hectar on an average yielding 30,000 kilogrammes.

Chicory with stalk and blossom.

Raking the roots into the washing canal.

Chicory is cultivated on a large scale chiefly in the departments of the north, Pas-de-Calais, Oise, the Ardennes and in Belgium. In France alone the area of the fields sown with this plant is said to exceed 8,000 hectars according to the information kindly given us by Alphonse Leroux, a specialist on this subject.

The argillaceous-silicious or argillaceous-calcareous soils when thick and slightly fresh are perfectly adapted for this plant, and particularly our rural districts from the Belgian border to Calais form a region very advantageous in this respect.

For the preparation of the soil, after the removal of the preceding harvest, the weed-extirpator is run over the field two or three times at intervals of eight days. By this digging operation the clogging plants are destroyed, after which the manure and the fertilizer are incorporated with the soil by deep ploughing. The field then during the whole winter is exposed to the influence of the atmospheric agents. In spring the soil is mellowed and sodium nitrate, superphosphate and potassium chloride are spread upon its surface. After this the sowing is done, which in France is performed in the second half of April or better from the 5th to the 25th of May.

Two principal varieties of coffee chicory are recognized: the *tete d'anguille* or *Palingkop* with curled leaves and the improved *Magdeburg*. As pointed out by J. van Seynhaeve, professor at the Agricultural Institute St. Jeane Berchmans at Avelghem (Belgium) these two varieties by hybridization, have yielded a great number of sub-varieties possessing agricultural and industrial properties more or less appreciated according to locality. The Palingkop variety is characterized by its regular root, its serrated leaves and red-colored ribs of the latter. It is preferred by Belgian growers, although its gross

picked either by hand or by means of a horse-drawn weeder. A few days later, when the fourth leaf is open, the thinning out begins, followed a little later by transplanting, by setting the stalks from 16 to 30 centimeters apart in the lines. Hoeing is done a number of times as long as the vegetation permits of walking between the lines, since a well cared for soil exerts a great influence upon the growing of the roots. In addition to this, the plants which show woody husks, are discarded since they depreciate the product.

In France the chicory is harvested from September 25th to November 25th either by hand or by ploughing. As fast as the plants in one line are pulled, the roots are gathered in heaps, after the removal of the leaves, and are roughly cleansed.

They are then transported to the factories where they are dumped in heaps over little canals covered with small wooden screens. There they are stored until subjected to further treatment. Then the workmen need only to remove the screens and rake the roots into the canals which serve as a hydraulic conveyor as in sugar refineries.

By that method the chicory roots are partly freed from adhering earth and arrive at the end of an endless screw which delivers them to the washer. At the top of this screw elevator the roots fall into a sheet-iron vat provided with a perforated bottom. In this vat is a shaft provided with arms, of which only the ends are seen in the picture, which agitate the roots in the constantly renewed water. The sludge passes through the holes in the bottom and is tapped off through a drain closed by a slide-valve.

From the washer the roots are dumped onto a shaking table, likewise provided with a perforated bottom, where they are drained while traveling toward a bucket-chain

The double roasting furnaces of Conflant shown in the accompanying photographs are built with two fire-grates and four spheres capable of roasting 3,000 kilogrammes per day. Two spheres rotate during the roasting operation while the other two are cooling down. The driving mechanism is sufficient for rotating three batteries of four spheres each by a single belt. As has been shown by Camille Guyot in his highly informing book on chicory (1911), the operation is usually finished in the cold, i. e., the apparatus is withdrawn from above the grate and is allowed to rotate for a certain time. Prior to and during the roasting operation, fatty substances are added which, besides giving a lustre, reduce the bitterness.

After cooling down, the chicory having become friable and brittle, passes into a series of crushers. After each crushing operation the broken material is passed through a selective sieve-drum and sifters adapted to divide the material into four sizes. These 6 million kilogrammes of roots after drying yield about 1,500,000 kilogrammes of dried chicory.

From these drying plants the chopped material is brought in bags or in bulk to the manufacturer whose first care is the cleansing of the material. At the roasting plant of Orchies (Nord) for instance, it is dumped into compartments provided with shakers, and thence to a powerful aspirator which removes the bits of straw, dust, etc.; thence it drops into a bolting-mill where it is freed from the heavier sand and assorted according to size. The finer pieces serve for the manufacture of the ordinary brands of chicory. The larger particles are used for the high-grade brands.

This operation is followed by roasting, which is done in sheet-iron spheres of one meter diameter revolving

above fire-grates heated by coke. One of the illustrations shows these roasters quite plainly.

Finally the roasted grains undergo a last manipulation, viz., the tinting, which consists in giving the grains a coating of impalpable chicory dust which imparts to them a regular tint and reduces their hygroscopic power by closing the pores. The methods used for effecting the tinting vary considerably, but the most widely used consists in reducing the residues left after crushing to a fine powder by means of granite cylinders revolving in a pan. On issuing from the cylinders the tinting powder is sifted and mixed in the proportion of 15 per cent to 20 per cent to the roasted material, after which the material is again sifted. The chicory is thus given the aspect of a perfectly coated light-colored grain entirely freed from an excess of dust. The last operation is that of packing the chicory either by hand or by machinery.

Since the war began chicory has been replaced by various products, among others the sweet acorn manufactured from the fruits of several oak varieties of Southern France, or by malt (germinated cereals, particularly barley which is roasted), or else by the fig coffee. For the production of the last-mentioned competitor of Mocha coffee, the figs of Smyrna or Corfu are cut into pieces either by hand or by a kind of chaff-cutter. The fragments are then dried upon hurdles and then roasted in a special kiln having its lower portion built in stone, and covered by an iron plate upon which is placed a rack provided with a conveying mechanism. Upon this rack likewise built of metal are placed 18 hurdles formed of frames of a hard wood over which is stretched a wire net upon which are spread about 5 to 6 kilogrammes of figs.

The hurdles, loaded one after the other, are inserted in place, starting at the top of the apparatus. When all are in place, the heat is brought up to 170 deg. Cent. During evaporation, which lasts from 2 to 3 hours, the operator withdraws successively each of the hurdles and mixes the figs by means of a hook. The only operation remaining now consists in grinding the roasted figs, which are then sold as coffee substitute possessing "sedative and fortifying properties," according to the opinion of grocers of France who, in default of anything better, sell it to-day to the dealers in "petit noir" for two cents.

Power With By-Product Recovery*

Relative Merits of Various Prime Movers in Relation to Scientific Utilization of Fuel

By T. Roland Wollaston, M. I. Mech. E. (London)

It is common knowledge that we have in coal, not only potential energy in the form of carbon and other constituents convertible into heat units and thence into useful work, but also, and in addition, valuable chemical-products, some of which may in many cases be secured as a clear set-off against the cost of the fuel used for power. With regard to the exact economic relation of by-product recovery to power generation there appears to be a considerable amount of misunderstanding and confusion, even among experienced engineers, and it is the aim of this article to set forth in clear and simple form the true position of one of the most interesting branches of the subject.

The development of prime movers in the form of the steam engine, the steam turbine, the gas engine, and the Diesel engine has been very rapid latterly. Prejudice exists in many quarters against all but the first of these; but it is beyond question that each type of prime mover can be successfully installed to fulfill makers' guarantees, and the prejudice referred to is unquestionably due to experiences which must inevitably be met during early stages of development of any invention. Troubles of this nature have been more frequent than they should have been in this country, as several engineering firms have placed their new types upon the market without sufficient trial and experiment. They have indeed adopted the unwise course of educating themselves or trying to do so, at their customers' expense, and have thus brought good systems into bad repute.

Let it be accepted, then, that the modern steam engine, steam turbine, or gas engine is a reliable motor if supplied with steam or gas, as the case may be, of suitable pressure and quality. Let it be further assumed that our steam engine or turbine will run on 14 pounds of steam and our gas engine on 75 cubic feet of producer gas per brake horse-power. These are quite reasonable figures, and the assumptions will enable us to leave the prime mover and to turn at once to consideration of the working media and their relative net costs of production.

In obtaining by-products from coal in the course of power generation the intermediate process of gasification must, of course, take place. Broadly, there are three processes of gasification in common use, namely:

(1) Retorting for illuminating gas, with the gas yield as the chief consideration, and with coke, tar, ammonia, and sometimes light oils as by-products.

(2) Retorting in coke ovens, with the coke yield as the chief consideration, and with gas, ammonia, tar, and sometimes light oils as by-products.

(3) Gasifying in producers with power or heating gas as the main product and ammonia and tar as by-products.

It is with the last of these only that these notes are concerned.

The most valuable by-product is ammonia, which, for simplicity of consideration, we may take as being produced in the form of the sulphate salt of commercial standard purity—24 per cent ammonia. The average price of this commodity from 1900 to the present date, delivered f.o.b. English ports, may be taken as £12 per ton There is every reason to believe that, following existing trade disorganization, the tendency will be toward higher values in the future.

The amount of sulphate obtainable from a given fuel is chiefly dependent upon the percentage of nitrogen therein, and the British coals available contain between 1 per cent and 3 per cent, with 1.3 per cent as a fair average. A notable feature is that the slacks and poorer qualities from a given seam are often quite as rich in nitrogen as the better class material. If it were possible to convert the whole of the nitrogen into sulphate of ammonia, coal containing 1 per cent of nitrogen would yield about 1 cwt. of sulphate per ton. Owing to the excessive temperature at which coke ovens and retorts are usually worked much of the nitrogen is destroyed, and yields of sulphate vary between 15½ pounds and 23 pounds per ton per 1 per cent nitrogen. On the other hand, by the most widely known producer practice—the Mond system—the average yield of sulphate is about 70 pounds per ton of coal containing 1 per cent nitrogen, or, say, 90 pounds per ton with 1.3 per cent nitrogen fuel. At £12 per ton this means sulphate to the value of about 9s. 7d. per ton of coal gasified.

There will also be obtained approximately the same weight of tar, worth perhaps 20s. per ton, so that the gross value of by-products obtained in every-day practice is well over 10s. per ton of coal gasified. When it is remembered that at some collieries the cost of coal at the pit bank is less than 4s. per ton, the economic possibilities of the system are obvious.

The Mond system has been in use upwards of twenty years, and its owners, the Power Gas Corporation, Limited, of Stockton-on-Tees, have erected upwards of twenty producer gas plants to work under ammonia recovery conditions. Some of these are very large, capable of gasifying nearly 300 tons of coal per day, with a sulphate yield worth £150 per working day.

With such figures in evidence the question naturally arises: "Why does not this procedure become universal?" This question we will endeavour to answer, having in view throughout the line of development likely to ensue and to extend the field of operation.

In the first place, it has been stated above that at high temperatures the nitrogen in the coal is partially destroyed. This occurs in the ordinary type of gas producer as used in steel works and the like. As a means of maintaining the fuel bed in the producer at a lower temperature and avoiding this loss, Dr. Mond arranged to put through his producers a large amount of steam along with the air blast. This steam is partially split into its components, oxygen and hydrogen, the former going to form CO and the latter remaining as H in the ultimate gas; but a very larger proportion of the steam undergoes no change other than superheating, and has ultimately to be condensed out of the gas. Broadly, the amounts of steam put through Mond recovery and non-recovery producers are respectively, per ton of coal gasified, 2½ tons and ½ ton.

The resultant analyses of the respective gases, as given in the makers' catalogue are:

VOLUME PER CENT. (SATURATED AT 15 DEG. CENT.).

	Non-recovery gas.	Recovery gas.
CO	23.0	11.0
H	17.0	27.5
CH_4	3.0	3.0
C_nH_{2n} + benzol	trace	trace
CO_2	5.5	16.5
N + moisture	52.0	42.0
Total volume	100.0	100.0
Total combustible	43.0	41.5

It will be noted that Mond recovery gas is rich in hydrogen and low in carbonic oxide. For this reason it was formerly regarded with some degree of suspicion for gas engines, and even now there appears to be prejudice against it among those who use gas for high temperature furnace work, their aim being usually to secure as high a percentage of CO as possible in the gas.

If Dr. Mond's procedure—with excess steam put through his producers—is solely to secure gasification at low temperture, and if it may be implied therefrom that the excess steam plays no part other than this in giving a high sulphate yield, there ought surely to be other and preferable methods of securing that end. The author, who makes no pretensions to expert chemical knowledge, learns on inquiry that there should be no need for excess steam to effect the chemical reactions consistent with good recovery.

If a producer gas having analysis more nearly in line with the first column above could be obtained along with a corresponding yield of sulphate of ammonia great advantages would accrue; for example:

(1) The gas would have wider utility for both heating and power purposes.

(2) The plant would be smaller and cheaper.

(3) The cost of generating the blast steam, a factor which has militated more than any other against progress, would be reduced, if not wiped out altogether.

Of this steam required for blast in a Mond recovery producer, say, 2½ tons per ton of coal, some ¾ ton is obtainable from the cooling plant, leaving a balance of 1¾ tons to be separately generated either by direct-fired or gas-fired boilers. Either method involves increased capital charges and labor costs, and the latter, while showing higher by-product yield, has a cumulative effect upon the capital and works charges. More gas is required to fire the boilers, therefore more steam to make the extra gas, in a sort of arithmetical progression which leads to figures distinctly surprising and startling to anyone preparing a scheme for the first time.

Gas leaves the producer at an average temperature of 550 deg. Cent. Before reaching the saturator, where the nitrogen is fixed, it has to be cooled down to about 80 deg. Cent. Down to, say, 150 deg. Cent., i. e., a margin of 400 deg. Cent., its heat is available for raising steam at 70 pounds per square inch pressure. What better method of preliminary cooling could be adopted than that of making the upper part of the producer into a boiler, thus at once generating abundant steam, helping to keep the producer cool, and cutting out much intermediate and costly preliminary cooling plant. The same thing is done in effect in nearly every form of suction gas plant.

It may be argued that the hot gases in the Mond system are to some extent utilized to superheat and supersaturate the blast. One's reply to this would be: "It is necessary to maintain the hot zones of the producer at only moderate temperature; why not do this by abstracting heat usefully in superheating and super-saturation of the blast?"

It may be argued, further, that the preceding paragraphs are mere speculations derived from "Mond" experience, but this would be only partially true, as several experiments have been made in this country and abroad on the stated lines, and one gentleman, Mr. Quintin Moore, in association with the well-known firm, Dowson and Mason, Limited, has patented and marketed such plant with quite considerable success.

Mr. Moore's producers are oval in cross section and are provided in their upper portion with an annular jacket, which is in effect a boiler. The oval section provides a means for radiating away the excessive heat of the lower fuel zones. An analysis of the result of working this apparatus, given in one of Messrs. Dowson and Mason's pamphlets, shows that, when recovering ammonia equal to 90.5 pounds of sulphate per ton of coal, the total weight of steam used per ton of coal was one ton, of which about half was generated by the annular boiler and through the agency of waste heat. The gas analysis given is:

CO	18.4
H	26.0
CH_4	2.2
CO_2	11.6
N	40.0
Water vapor	1.8
Total volume	100.0
Total combustible	46.6

*From *The Engineer*.

No information is available with regard to the relative fuels from which the foregoing analyses were derived, nor the relative efficiencies, nor is it suggested, as the figures might be taken to indicate, that the "Moore" producer necessarily gives better gas than the "Mond." The significant point is that the former, on a supply of half a ton of steam from extraneous sources, gave as good gas, with an equal ammonia yield, as the former, which required $1\frac{3}{4}$ tons of steam. The relative CO and H volumes in the two gases are worth noting. The author is of opinion that natural development will, as previously suggested, enable all the steam required for blast to be self-generated, and will, while maintaining or possibly improving the heat efficiency, provide better gas, for example, in percentage of CO.

So far as producer gas, with ammonia recovery, for gas engines or furnace firing is concerned, no more need here be said; but when one has in view steam raising, there are other points to be carefully considered. Hitherto in the majority of cases in which boilers have been fired by producer gas the boilers, either of the Lancashire or water-tube type, have been already in existence and altered to gas firing. Such boilers are specifically designed for coal firing and are, of course, good designs for the purpose. But on changing to gas firing the results have generally been disappointing, not so much on account of reduced heat efficiency as on account of decreased output. It is well known that heating surface in boilers of this type varies in value in reference to location. For example, the flues immediately over and round the grate of a Lancashire boiler, coal fired, are responsible for a very considerable percentage of the total evaporation. When gas fired there is no equivalent for this, with the result that a given boiler which would evaporate 7000 pounds of water if direct fired will rarely evaporate more than 5000 pounds if producer gas fired. It was not designed for, nor can it be expected to fulfil, the purpose. Again, if one assumes that a reasonable boiler efficiency is 70 per cent—i. e., that 70 per cent of the heat units in the coal fed appear in the steam from feed temperature—in gas firing one can hardly expect more than 70 per cent producer efficiency, so the total efficiency of combined producer and boiler will be less than 50 per cent. But, on the other hand, given a good and constant gas, it is possible with specially designed boilers to get much higher efficiencies from gas than from coal, and, which is of vital importance, steadily to maintain these high efficiencies without difficulty. A gas-fired boiler has been made which gave consistently 98 per cent heat efficiency, while by means of the well-known "Bonecourt" system 92 per cent efficiency is guaranteed. Other adaptations of well-known boilers fitted with special burners are claimed to show from 85 per cent to 87 per cent heat efficiency. The ideal gas-fired boiler for work purposes is perhaps not yet available, but that it will come, and will show somewhere in the neighborhood of 90 per cent efficiency, can hardly be doubted. Taking, again, the gas plant efficiency at 70 per cent, one may then expect a combined efficiency of about 63 per cent.

The relative merits and demerits of various prime movers in connection with ammonia recovery may now be compared. In drawing this comparison one may first state—a fact that is almost obvious—that the advantages of a recovery system become more apparent as the size of the plant increases; but the avowed object of these notes is to demonstrate that by-product recovery will be worth while in many power installations of ordinary size. Another point importantly affecting results is load factor, and this influence is twofold. First, as regards capital charges, these remain substantially the same no matter whether the plant is worked at full load for twenty-four hours per day or at half load for ten hours per day. Secondly, continuity of operation is important as affecting yield of by-products.

To take an average case, therefore, a power plant of 1,500 brake horse-power is assumed working day and night, 7000 hours per year at average 1000 brake horse-power load.

CASE 1.—*Capital Costs.*

Condensing steam engines, high class, aggregating 1500 brake horse-power	£6,500
Steam boilers and auxiliaries for same	2,625
Buildings, foundations and chimney	1,800
	£10,925

Running Costs on 1000 *Brake Horse-power Average Load at* 2 *Pounds of Coal per Brake Horse-power.*

6250 tons of coal at 12s.	£3,750
Oil and stores, say	375
Labor, ten men, two shifts, at £10	700
Maintenance, $1\frac{1}{2}$ per cent on £10,925	164
Interest and depreciation, 10 per cent on £10,925	1,092
Total running cost per annum	**£6,081**

CASE 2.—*Capital Costs.*

Gas engines aggregating 1500 brake horse-power with auxiliaries	9,000
Pressure gas plant, non-recovery	2,800
Buildings and foundations	1,800
	£13,600

Running Costs on 1000 *Brake Horse-power Average Load at* $1\frac{2}{5}$ *Pounds of Coal per Brake Horse-power.*

4375 tons of coal at 12s.	£2,625
Oil and stores, say	375
Labor, ten men, two shifts, at £70	700
Maintenance, $1\frac{1}{2}$ per cent. on £13,600	204
Interest and depreciation, 10 per cent on £13,600	1,360
Total running cost per annum	£5,264

CASE 3.—*Capital Costs.*

Gas engines aggregating 1500 brake horse-power with auxiliaries	£9,000
Recovery gas plant, Mond system, and exhaust boilers	5,400
Buildings and foundations	2,150
	£16,550

Running Costs on 1000 *Brake Horse-power Average Load at* $1\frac{3}{5}$ *Pounds of Coal per Brake Horse-power.*

DR.

5000 tons of coal at 12s.		£3,000
Oil and stores, say		400
Labor, fourteen men, two shifts, at £70		980
Acid, 201 tons at 35s.		352
Handling sulphate at 6s. 8d		67
Maintenance, $1\frac{1}{2}$ per cent on £16,550, say		250
Interest and depreciation, 10 per cent on £16,550		1,655
		£6,704
CR.		
By 201 tons sulphate at £12	£2,412	
By 201 tons tar at £1	201	
		2,613
Total running cost per annum		£4,091

CASE 4.—*Capital Costs.*

Condensing steam engines as in Case 1	£6,500
Ordinary boilers gas fired with extra boilers to make up for inefficiency and producer steam	3,600
Recovery gas plant, ordinary type, to fire all boilers	11,500
Buildings and foundations	3,300
	£24,900

Running Costs on 1000 *Brake Horse-power Average Load, say, to Raise* 14,000 *Pounds of Steam Net per Hour for Power with Additional Steam for Blast.*

DR.

13,200 tons of coal at 12s.		£7,920
Oil and stores, say		400
Labor, twenty men, two shifts at £70		1,400
Acid, 530 tons at 35s.		927
Handling sulphate at 6s. 8d		177
Maintenance, $1\frac{1}{2}$ per cent on £24,900		373
Interest and depreciation, 10 per cent on £24,900		2,490
CR.		£13,687
By 530 tons sulphate at £12	£6,360	
By 530 tons tar at £1	530	
		6,890
Total running cost per annum		£6,797

CASE 5.—*Capital Costs.*

Condensing steam engines as in Cases 1 and 4	£6,500
Special gas-fired boilers, 90 per cent efficiency, to generate $\frac{10}{9}$ times as much steam as coal-fired boilers	2,625
Recovery gas plant of proposed self-generating steam type	7,800
Buildings and foundations	2,600
	£19,525

Running Costs on 1000 *Brake Horse-power Average Load, say, to Raise* 14,000 *Pounds Net Steam per Hour.*

DR.

6945 tons of coal at 12s. per ton		£4,167
Oil and stores, say		390
Labor, sixteen men, two shifts, at £70		1,120
Acid, 280 tons at 35s.		490
Handling sulphate at 6s. 8d		94
Maintenance, $1\frac{1}{2}$ per cent on £19,525		293
Interest and depreciation, 10 per cent on £19,525		1,952
		£8,506
CR.		
By 280 tons sulphate at £12	£3,360	
By 280 tons tar at £1	280	
		3,640
Net running cost per annum		£4,866

The basis figures used in the above estimates will, it is believed, be accepted as fairly in accord with average experience. Some rather interesting conclusions are suggested by these estimates. For example:

(1) Case 4 illustrates that a recovery gas-steam scheme on ordinary lines will not pay for low or moderate powers. The capital outlay is very large and the resultant running cost considerably higher than a simple steam scheme on ordinary lines. If, however, the coal were cheaper, the output greater, and the load factor better, analysis will readily show that this might be, and indeed has proved to be, a paying proposition.

(2) Case 5 illustrates that with the improved type of gas by-product plant suggested and special gas boilers it would be possible, on 1000 horse-power average load, to beat any other type of power plant except an installation of gas engines with recovery producers. If the suggested improved type of gas plant were used with the gas engine scheme it would show still better results. One has to remember, however, the strong prejudices in many quarters in favor of steam engines and turbines, and the admitted advantages of the latter as regards upkeep and overload facilities. Higher powers and load factor and cheaper fuel would again greatly improve the relative running cost figure.

(3) In Cases 1 and 2, those of ordinary steam or gas power plant, the running costs may be taken approximately proportionate for any output. Mere increase in size—fuel cost and load factor remaining the same—would not affect the relative cost per horse-power.

(4) For simple power plants of medium size, as, for example, at small electrical stations, cotton mills, and the like, working on low load factor or short hours, it would seem that by-product recovery schemes offer less inducement than might at first glance be imagined, though the author knows of one or two which show excellent results.

(5) While from the above it is apparent that well-devised by-product recovery will show a fair return on outlay in suitable purely *power* plants, the chief value of the system comes in when power generation is associated with heating processes, as, for example, in steel and iron-works, chemical works, and the like. In industrial processes involving furnaces, stoves, kilns, or ovens directly fired by coal or coke, it may be broadly taken that a change over to producer gas firing from central plant will directly save 30 per cent of fuel. Add to this a net by-product rebate of 4s. or 5s. per ton of coal consumed and the economy becomes obvious.

Cleaning Discolored Marble

FREQUENTLY when marble is exposed, as in a cemetery, where it is more or less sheltered by trees, it is disfigured by lichens and other vegetable growth.

In many instances this growth has died and become brown or black in color. All such discolorations may be readily removed by soda lye of moderate strength, about 5 per cent. That which is rotted is dissolved, and the remainder is soon disintegrated.

The following directions answer well: A box of concentrated lye, containing about twelve ounces of caustic soda is dissolved in a two-gallon bucket of water. Spread this over the stone with a small cheap scrubbing brush, made of vegetable fiber, preferably provided with a handle so as to avoid getting the lye upon the hands, the clothes or the shoes. After ten minutes or more pour water over the stone to wash off most of the lye and then rub it a little with the brush, using some sand if necessary, and the stain will be removed.

Of course this liquid has no effect upon the stone itself, and is most easily washed away. So far as the wash falls upon the ground, it will improve rather than harm any grass or other plants. Should the lye remain upon the skin, it may occasion an ugly sore. If splashed upon the clothing, the prompt application of a solution of sal ammoniac will prevent corrosion of the goods.

Indicating Temperatures

A SIMPLE method of indicating or ascertaining temperature is by means of certain metallic salts the melting temperatures of which are known. Such salts have been prepared to indicate a range of temperatures between 425 and 2,425 deg. Fahr., and the temperature of a bar of iron in a furnace can be ascertained by placing on it some of the different mixtures of salts and noting which one melts. In the same way a bar of steel may be heated to a required temperature with practical certainty by placing some of the salt that melts at the required temperature on the bar when it is put into the furnace and heating until the salt fuses.

Recent Progress in Astrophysics—I*

Many Important Discoveries That Add to Our Knowledge of the Heavenly Bodies

By Prof. C. G Abbot

According to the definition of the word by the late Prof. Newcomb in the last edition of the Encyclopædia Britannica, "Astrophysics is that branch of astronomical science which treats of the physical constitution of the heavenly bodies." Interpreting this definition in a manner somewhat narrower than that which is generally accepted in astronomical circles, Prof. Newcomb, in his article on astrophysics, mentioned the principal conclusions of the science to be that the heavenly bodies are composed of like matter with that which we find to make up our globe; that as a rule the incandescent heavenly bodies are mainly composed of gas, or of substances gaseous in their nature; and that the temperature of the great heavenly bodies is extremely high. He thus omitted from the province of astrophysics the study of the motions of the celestial objects and their parts by aid of the spectroscope, although this certainly has a bearing on the physical constitution of these objects. Information of fundamental importance in relation to the nature of the heavenly bodies and the evolution of the universe has resulted from investigations of the radial velocity of stars by the spectroscope; and this is supplemented and confirmed by observations with the telescope alone. Hence I shall not confine myself strictly in what follows to Prof. Newcomb's definition of astrophysics, but shall include the discussion of several subjects which have at least an astrophysical bearing, though not strictly, perhaps, astrophysical in themselves.

THE WAVE LENGTHS OF LIGHT

All modern spectroscopic progress depends upon the exact knowledge of the wave lengths of the lines of absorption or emission of the chemical elements. Long ago it was discovered that sodium and its compounds, when heated to incandescense, gave out a yellow light, which when examined by the spectroscope, resolved itself into two lines of wave lengths 5,890 and 5,896 Angström units. It was also found that when sodium vapor was interposed between a source of white light, like the electric arc, and the slit of the spectroscope, there would be found in the place of the bright yellow lines of sodium two dark lines of absorption, where light of the arc spectrum was taken away. Similarly, in the spectrum of iron, a great number of bright lines are found in the green; and if iron vapor is interposed between an electric arc light and the slit of the spectroscope, a great number of absorption lines will be found at the corresponding places. Also in the spectra of the sun and of many of the stars there occur dark lines corresponding exactly in place to the bright lines of the spectra of the chemical elements found upon the earth's surface. From these indications it is clear that these chemical elements exist as vapors in the substance of the sun and stars. The number of chemical elements in the sun and stars is so considerable and the number of their spectrum lines is so great, that the solar and stellar spectra are thronged with dark lines, so that it takes the most exact knowledge of the positions of the lines to insure for them a correct interpretation.

But in recent years a great deal more has been learned by the aid of the spectroscope in regard to the sun and stars than of their mere constitution, for it is found that although the spectrum lines occur almost exactly in the same position in the spectra of the heavenly bodies that they do in the spectra of the laboratory, yet there are slight and very significant deviations of position which are attributable to the motion of the heavenly bodies to or from the earth. For, just as in the whistle of a locomotive, there is a sharping or flatting of the pitch, depending upon whether the locomotive is coming toward the observer or going away from him, so in the light of the stars there is a displacement of the spectrum lines toward the violet or toward the red, according as the star is approaching toward or receding from the earth. One may go even farther, and say that there is a difference in the position of the spectrum lines of the sun according as we take the light from one edge of the sun or the other. For one edge is approaching the earth by virtue of the rotation of the sun, while the other is receding. It is also shown that the position of the spectrum lines depends upon the pressure of the gases in which they are produced, so that it is possible to determine by exact measurements the pressures under which the gases lie in the sun and stars, although these are so extraordinarily remote that it takes light minutes or years to reach the earth from them. Finally, it has been shown by Zeeman that the form of the spectrum lines of the chemical elements differs according to whether the light is produced in a magnetic field or not. Accordingly it is possible to determine from measurements of the solar spectrum whether magnetic fields exist in the sun, and, if so, to what intensity they rise.

All these kinds of measurement, which depend upon extremely slight displacements of the spectrum lines, evidently require that great accuracy shall be obtained in the determinations of the positions of these lines in the laboratory. When about the year 1895 Rowland completed his investigation of the spectrum of the sun and of the chemical elements, it was thought that the last word had been said upon this, and that no greater accuracy of positions of the spectrum lines was necessary, or indeed possible, than he had obtained. But in recent years it has been found necessary to go over the whole ground again, and to determine the positions of the lines of the chemical elements and the lines in the spectrum of the sun with a still greater accuracy than that of Rowland. This work has been taken up under the auspices of the International Solar Union, and is now approaching a satisfactory completion.

In the year 1893 a remarkable piece of work was carried out by Prof. Michelson (now of the University of Chicago) in the measurement of the wave length of light in terms of the standard meter of the International Bureau of Weights and Measures at Paris. Several of the spectrum lines were investigated, and among them the red line of cadmium, whose wave length as determined by Michelson is 6438.4722 Angström units.[1] In pursuance of the investigations recently recommended by the International Solar Union, Messrs. Fabry and Perot remeasured the wave length of the cadmium line and found the value 6438.4696, which, it will be seen, differs by less than 3 parts in 6,000,000 from that obtained by Michelson. On this value of Fabry and Perot will rest the system of wave lengths adopted by the International Solar Union.

It had been determined at the meeting of the Union on Mount Wilson in 1910 that only wave lengths which are independently determined with satisfactory agreement by three observers with the most approved apparatus should be accepted as secondary wave-length standards. In pursuance of this action of the Solar Union, Messrs. Fabry and Buisson in France, Pfund at Baltimore, Eversheim and Burns in Germany, have been determining with the highest possible accuracy the wave lengths of certain lines in the spectra of iron and nickel, selected at nearly equal intervals of wave length. About 85 such lines have now been measured with satisfactory agreement in three or more independent investigations, and have been adopted by the International Solar Union as secondary standards of wave length. These lines cover the spectrum from a wave length 3370.789 Angström units, which is far beyond the visible limit of the spectrum in the violet, to wave length 6750.163 Ang-

* Annual report of the Smithsonian Institution, 1913.

[1] The Angström unit is one ten-billionth of a meter.

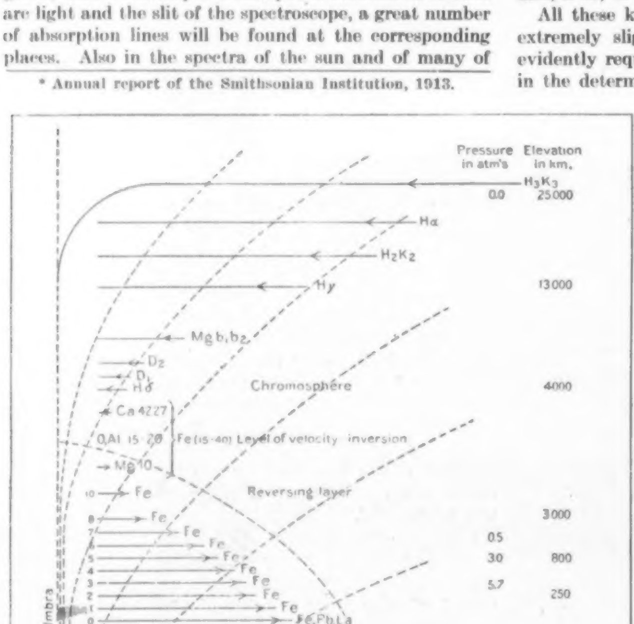


Fig. 1.—Vertical section of reversing layer and chromosphere, showing distribution of radial velocities of sun spots.

The lengths of solid lines are proportional to radial displacements of the corresponding Fraunhofer lines. Arrows indicate direction of flow. The rounded head of the cyclonic disturbance is suggested by the broken-line curve enveloping the outward velocities. Broken lines with arrows refer to possible velocities below the accessible levels. Lines of force of the magnetic field are indicated in the usual way.—From Report on Mount Wilson Solar Observatory, by George E. Hale, Twelfth Year Book Carnegie Institution of Washington, 1913.

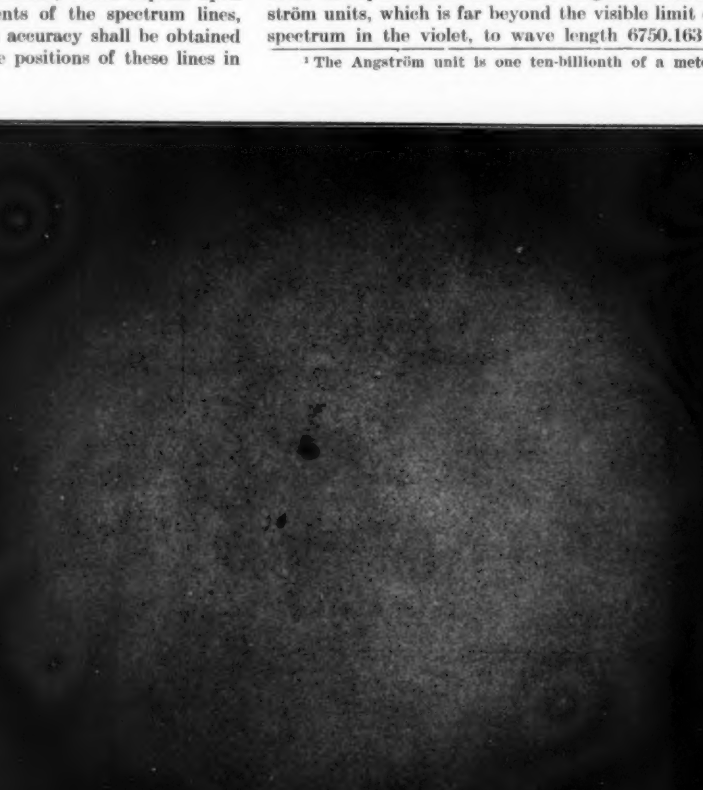


Plate 1.—Solar photograph showing sun spots.

From the *Astrophysical Journal*, Vol. 32, plate 1, Fig. 1, article of Slocum, page 24.

ström units, which is near the limit of the visible red. It is expected that further investigations will carry the lists of secondary standards as far as wave length 2,000 in the ultra-violet, and perhaps as far as wave length 10,000 in the infra-red. The astonishing accuracy of the results obtained may be inferred when it is said that the three independent investigations generally agree to the seventh place of significant figures. Also St. John and Ware have investigated the consistency of the standards, each to each, by determining other wave lengths independently by interpolation from several different standards, and are of the opinion that adjustments in the seventh place of significant figures are hardly ever necessary, and will perhaps never exceed 0.002 Angström units in any case. Investigations are now on foot by St. John and Ware, Goos, Burns, and others to determine a large number of tertiary standards of wave lengths intermediate between these secondary standards, and it is hoped that good agreement in regard to the tertiary standards will soon be obtained.

It is found necessary in this work to specify the strength of the electric current, the length of its arc, and the position of the slit of the spectroscope with respect to the arc in order to get satisfactory results. It now remains to go over the whole system of spectra of all the chemical elements and determine the positions of their lines with respect to these standard lines of iron, nickel, and barium which have been adopted, and further to go over the whole solar spectrum and to determine the position of its absorption lines with respect to these standards.

Although this will involve an enormous amount of careful work in photography of the spectrum and in the measurements of the results, a work which will be so exacting as to appear at times almost a drudgery to those who are engaged in it, yet like other good work it is almost beyond question that it will yield unexpected fruits of discovery in addition to those of investigations of the nature of the sun and of the stars for which it is primarily undertaken.

Solar Problems.

The Nature of Sun Spots.

Soon after the invention of the telescope, Galileo, in the year 1610, observed spots on the sun. They continued to be observed by many persons, and in the middle of the nineteenth century it was found by Schwabe that the appearance of them was periodic. The average interval between successive maxima or minima of sun spots is 11 years, but individual periods range from 8 years to 15 years in length. The years from 1905 to 1910 were distinguished for large numbers of sun spots, and the years 1910 to the present time for very small numbers. We are now probably just at the beginning of a new sun-spot maximum period, so that the report of spots being seen upon the surface of the sun need not surprise us. Sun spots, as seen in the telescope, consist of a dark central part called the umbra, and a less dark shading around it called the penumbra. The appearance of the sun when large spots are upon its surface is shown in the accompanying figure (plate 1).

The nature of sun spots has long been a subject of investigation. In the last few years comparatively satisfactory conclusions have been drawn. It appears that sun spots are cooler than the surrounding surface of the sun. This is shown in several ways. In the first place, a delicate electrical thermometer, called the bolometer, in the hands of Langley and subsequent investigators, has shown a decreased temperature when exposed to the rays from sun spots, as compared with its temperature when exposed to the rays of the surface of the sun close by. In the second place, the spectrum of the sun spot is found to differ from the spectrum of the solar surface in the immediate neighborhood in certain very characteristic ways. This difference has been investigated by the Mount Wilson Solar Observatory. A photographic map of the sun-spot spectrum as compared with the spectrum of the sun's surface has been published by that observatory. The accompanying illustration (plate 2) is taken from an interesting portion of such a spectrum map.

It shows in the first place that a large number of lines are found in the sun-spot spectrum which are either very indistinct, or not to be seen at all in the spectrum of the sun's surface. It shows in the second place that certain lines are broadened, or made double, in the spectrum of the sun spot as compared with the spectrum of the surroundings. In the third place, that some lines are weakened and some strengthened in sun spots, as compared with those of the surroundings. The cause of the numberous additional lines in the sun-spot spectrum has been found to be the presence of certain compound substances, such as calcium hydride, magnesium hydride, and certain oxides, as, for example, that of titanium. The cause of the different intensity of certain lines in the spectra of the spot and of the surroundings is shown by Hale, Adams, and Gale to be the decreased temperature of the sun spot. This conclusion they confirm, line for line, by noting the behavior of the lines of the corresponding chemical elements when observed at different temperatures, by the aid of the spectroscope, in the laboratory.

The doubling or widening of the lines of the sun-spot spectrum was found by Hale to be due to the presence in sun spots of a magnetic field. This observation depends on the discovery of Zeeman that the spectrum lines of the chemical elements, when produced in a strong magnetic field, are often doubled or trebled or made even more complex. The component lines, so produced, depend as regards their position, number, and the polarization of their light, upon the strength and direction of the magnetic field through which they are observed. The relation of magnetization to the polarization of the light was the feature of the matter which laid the subject of the widening of lines in sun spots open to Hale's investigation. By the use of proper apparatus for the polarizing and analyzing of light, he was able to remove or alter the individual components of the spectrum lines in a manner adapted to show the magnetic field existing in the sun spots where the light was produced. This most interesting discovery he has now pushed still further, and has examined the magnetic field of the whole surface of the sun. He finds that there exists upon the sun a magnetic field similar in many of its characteristics to that which exists in the earth, although the intensity of the field is so extremely slight that the shifts or alterations of spectrum lines caused by it are almost beyond the possibility of disclosure.

Recently it was shown by Evershed that in the penumbras or darkened edges of sun spots, there are found shiftings of the spectrum lines which show that the vapors are moving outward from the center of the spot, or umbra, toward the outlying parts of the penumbra. Later investigation shows that this outflow of the gases from the umbra toward the outer part of the penumbra is accompanied by a motion of rotation also around the umbra, so that the motion resolves itself into a whirling of these vapors or gases similar to that which is found in a waterspout. This has a very important bearing on the explanation of the magnetic field in

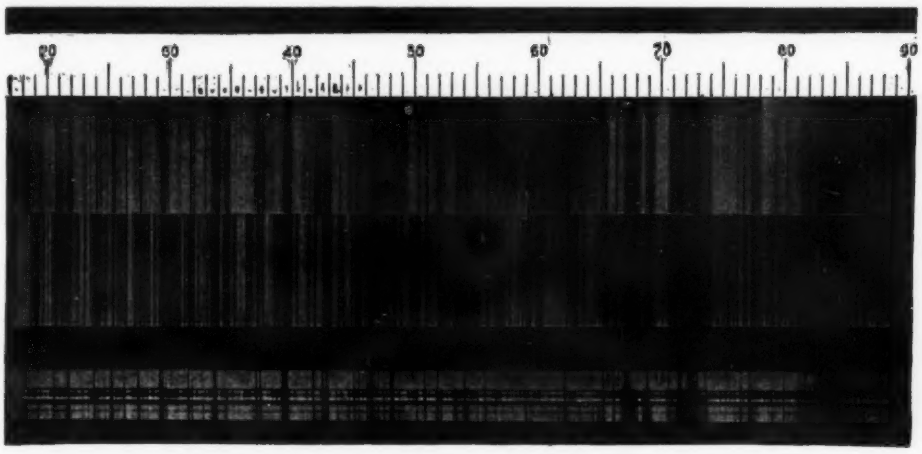


Plate 2.—Sun spot spectrum map by Mount Wilson Observatory.

From Abbot's "The Sun" (copyright, 1911, D. Appleton & Co.), plate 17, page 210. (By courtesy D. Appleton & Co.)

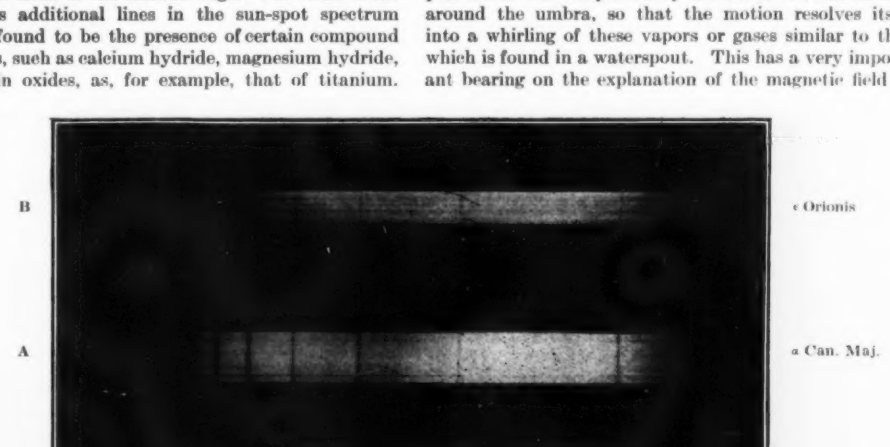


Plate 3.—Typical stellar spectra.

From Annals Harvard College Observatory. Vol. 64, No. 4, Plate 1.

slun spots discovered by Hale, for it was shown by Rowland many years ago that an electric charge in motion has the property of an electric current of producing a magnetic field. Thus if there are in sun spots materials under dissimilar electric conditions, and these materials be whirled as in a waterspout, they must necessarily produce a magnetic field. St. John, of the Mount Wilson Solar Observatory, has made a thorough investigation of the motions of the vapors in the neighborhood of sun spots, using the spectrum lines of many of the chemical elements. He finds that the displacements of the spectrum lines of iron and some other well-known metals indicates a motion away from the umbra. The motion, on the other hand, of magnesium and hydrogen and some other of the lighter chemical elements is toward the umbra. It was also shown some years ago in a photograph by St. John that hydrogen gas is sometimes sucked into the center of a sun spot.

All these various lines of evidence indicate that a sun spot is a whirl in the gases of the outer part of the sun, analagous to a water-spout, and that this whirl comes from within outward. Associated with the whirl there is produced a magnetic field, and associated with the outward motion of the materials a decrease of pressure. The decreased pressure of the gases causes their expansion and consequent cooling, so that the coolness of the sun spot is thereby explained. As the gases spread out at the surface of the sun, the lighter gases—hydrogen and others—which are found in the outermost solar layers, are sucked into the partial vacuum at the center of the whirl.

SOUNDING THE SOLAR DEPTHS.

St. John's investigations of radial motion in the neighborhood of sun spots have led him to further very interesting results. For it appears that if one takes the various lines of iron as found in the sun's spectrum, classifying them according to their faintness after the manner of Rowland, the fainter lines show greater displacements and thereby more rapid outflowing in the sun-spot whirls than do the brighter ones. In fact, the brightest iron lines show less than a fourth as great displacements as do the fainter ones. Now, it appears from various lines of reasoning that the fainter lines should be the ones that are formed at the greatest depths, so that St. John is able to arrange the iron spectrum with reference to faintness and with reference to velocity of outflow in sun spots in a series which very probably indicates a progressive depth of sounding below the surface of the sun. Then corresponding to this iron scale, if he takes the lines of the other chemical elements, comparing them line by line as regards velocity of outflow with the velocity shown by his iron scale, he may arrange all the chemical elements in terms of the iron scale, in the order of their depths of occurrence below the sun's surface.

In this way he finds, as is indeed indicated by other lines of research, that the heavy chemical elements will lie the lowest, and *vice versa*. Corresponding to this arrangement it is natural to find that the lines of calcium, sodium, magnesium, and hydrogen indicate a flow of greater and greater velocity in the opposite direction from those of iron, so that these elements are arranged above the uppermost level of the iron lines in a progress outward from the general solar surface. Thus, as shown in figure 1, we may have the arrangement of the vapors as they exist in the sun, from the hydrogen at the highest level down to the elements like lead, lanthanum, barium, at relatively low levels. Such elements as uranium (and radium, if it exists in the sun) are so very high in atomic weight that they lie very deep down in the sun and do not give solar-spectrum lines at all, so that we shall probably not obtain direct proof of the existence of radium in the sun on account of the low level at which it must lie if present there. We have, to be sure, long known of the existence in the sun of helium, which is a product of the disintegration of radium. This may, perhaps, indicate that the parent substance, radium, is also present in the sun, but of this there is no certainty.

(*To be concluded.*)

The Power of Telescopes

By W. E. Woolard

A TELESCOPE consists of an object-glass which collects rays from any body in front of it and forms a small image of this object according to physical laws. This image is magnified by an eyepiece as though it were a real object. The eyepiece acts as a low-powered microscope. The size of the image does not depend upon the size of the lens as much as upon focal length.[1] The longer the focal length the larger the image, but as the light forming it is spread over a large surface it is fainter than an image of a short focal length lens. This is important in photographic work where it is of more advantage to have a photograph of a large faint image, requiring a longer exposure than one of a small brilliant image with short exposure, requiring an after enlargement. In photographic work, of course, the eyepiece is removed and the photograph is of the same size as the original image, which is always comparatively small, even in large telescopes, unless smaller lenses are used to magnify it a few times, as is often done. An unmagnified image of Mars in the Yerkes telescope is about one eleventh of an inch across. Of course, this article applies to specula as well as lenses. But in some things, as the scrutiny of the moon's surface, visual work is ahead of photographic, and in visual work the size of the image is not as important as its brightness.

Why is a large telescope more effective than a small one? The sizes of the images do not differ enough to make much difference. It is only after we have magnified the image of the objective by an eyepiece that we can see anything, and every telescope has a whole battery of eyepieces of different magnifying powers. The more we magnify an image the larger it becomes of course, the better we can see the details, and the more we can see; in other words, it brings the object closer apparently, and the closer we are to anything the better we can see it. Of course, as the image is magnified, the total amount of it that we can see at any one time decreases. Now why can't we magnify the image of a small lens until we get it as large as the magnified image of a large lens and consequently be able to see just as much? We will undertake to answer this question.

Every point of an object sends out rays in every direction to an infinite distance if not stopped by an opaque object, and consequently to every point on the lens. As points have position only, the number of rays is infinite, and in passing through the lens all these rays are refracted to a point. Thus, as each point is at a different place in the object, and consequently in the image, and since the image of each point resembles the real point, an image of the object is formed. Now only those rays which strike the lens go into the image, which is of a certain brightness, and it is clear that if more rays went into it, the image would be brighter. But the only way more rays could be caused to take part in forming the image would be to increase the size of the lens, consequently the light-gathering surface, as shown easily by a diagram. Therefore, the larger the lens the brighter the image, as more light is made to take part in forming the image. But what has this got to do with magnifying power?

In magnifying an object it is made larger, but the quantity of light necessarily remains constant. Consequently, the original illumination has to spread over a greater surface and the object grows apparently fainter. The higher the magnifying power the fainter the object grows, until finally it becomes so faint and indistinct that it cannot be observed. Furthermore, the imperfections of instrument and atmosphere are also magnified. Therefore, the brighter the image in a telescope, that is, the larger the objective, the higher the power that can be used advantageously, the closer the object can be brought, and the more can be discerned.

If a telescope had an objective one fifth of an inch in diameter we could see no more with it than with the eye, because it would grasp no more light. But if it were 100 inches in diameter, or five hundred times that of the pupil of the eye in the dark, it would grasp 250,000 times as much light as the eye, since the areas of two circles are to each other as the squares of their diameters. Hence, we could see 250,000 times as far, since it would bring things that many times as close. As a matter of fact, 18 per cent of the light is lost in a refractor. One advantage of large instruments, and an important one, lies also in their great focal length. For it is easily seen that for a given diameter, the image is larger the greater the focal length, although the image is always so small that the question of brightness and ability to stand magnification is very important in visual work, as explained above. But in photographic work the focal length is often enormously increased by combinations of mirrors and lenses, so that there is obtained a very large, though faint, image. Ritchey has thus photographed our satellite with a focal length of 150 meters. However, the larger an image of a given brightness is to start with, the more advantageous it is for visual work, particularly for certain lines of astronomical work. For some things a large telescope is not desirable.

So now to sum up: The *larger* the *objective*, and consequently the *telescope* and *focal length*, the more light it collects, and the *brighter* and *larger* the telescope's *image*. Consequently, the more the image can be *magnified*, and still remain distinct, that is, the *closer* it can be brought, the more of detail can be seen in it.

It is thus simply a question of magnification, or in photography, exposure, depending upon the light-grasping power or diameter of the objective. As far as geometrical theory goes, we can see as much with a small telescope as with a large one, for by putting a physician's microscope onto a 4-inch telescope we could make it as powerful as Herschel's reflectors. But in practice this is impossible for the following reasons:

First, the image would be so faint and imperfect that nothing in it could be made out, for atmospheric and instrumental imperfections are correspondingly magnified. Second, the effect of light having a wave-length is such as to give no advantage in using a magnifying power of over 50 or 100 for each inch of aperture. Third, as achromatism is not perfect, the increase of the aureoles sets a limit, and of course the numerous imperfections also set a very low limit. In practice, it is seldom possible to use a power of over thirty for each inch of aperture.—*Popular Astronomy.*

[1] The focal length of a lens depends upon the curvature of its surfaces, not its diameter. If ordinary proportions are given to the lens, the focal length becomes a function of the diameter.

Identifying Minerals and Precious Stones

THE mineralogist is frequently confronted with the problems of identifying and valuing precious stones, for although an experienced dealer may be able to tell the genuineness of a gem at sight, scientific tests are frequently necessary to make certain.

When a large quantity of a mineral is available, various chemical tests may be applied, but when a single cut stone is presented for identification, chemicals may not be used. Dependence is then placed on physical tests which do not affect the material in any way. Two of these tests are, hardness or resistance to scratching, and specific gravity or heaviness with reference to water. Even these, however, are sometimes not applicable, and the optical properties must be tested. These include color, effect on polarized light, and the index of refraction. One or another of these methods is applicable in practically every case, but it is rarely wise to depend on a single test; the more ways in which a conclusion can be reached, the more certain it is likely to be.

Dr. Edgar T. Wherry, assistance curator of the Division of Mineralogy and Petrology of the U. S. National Museum, has recently worked up a method of identification especially well adapted to gems, though not without application to other mineralogical work. This system employs the microspectroscope, a microscope eyepiece containing a small prism for the purpose of splitting or dividing the light from the source into the spectrum or series of colors into which all light may be divided. A brilliant white light is used for this purpose, such as that given off by a Welsbach burner. As the examination must be carried on in as dark a place as possible, so that the eye will be sensitive to slight light effects, the burner is surrounded by a dark chimney and only a narrow beam of light is allowed to escape. This beam is focused on the side of the specimen by means of a lens or mirror, and its path is viewed through the microscope, using the microspectroscope eyepiece. In examining colorless gems and crystals, like the diamond, only the continuous spectrum is shown, with its colors ranging from red, through orange, yellow, green and blue to violet; but if the specimen is colored by the presence of certain chemical elements or dyes, light of some color will be absorbed by it, and one or more dark bands will appear in the spectrum where the eliminated color would ordinarily be. The positions and numbers of these bands are highly characteristic of certain substances, and therefore serve to identify gems and minerals colored by these substances. The location of the bands is found by the use of a very finely divided scale within the instrument which reads in 2,500,000ths of an inch.

The ruby owes its color to the presence of a small amount of an oxide of chromium, and when combined in this form and examined as described above, that element shows a black band toward the extreme red end of the spectrum, separated from the invisible region beyond the red by a narrow bright line. When an unknown stone exhibits this type of spectrum in the microspectroscope, it may be identified as genuine ruby with absolute certainly. Synthetic rubies, which are identical with the natural ones in every respect, also show this type of spectrum, but the bits of red glass, which owe their color to copper or gold or to the rare element selenium, so often cut and sold as rubies, do not show this type of spectrum and can at once be detected.

Sapphires can also be positively identified by this same method, only here the behavior is reversed; true sapphires show no absorption bands, but a clear spectrum, while their blue glass imitations have several strong bands replacing the colors eliminated from the spectrum. This method has also proved valuable in the identification of many transparent or fairly translucent precious stones, including the emerald, garnet, tourmaline, turquois, beryl, and topaz. Considering the fact that it can be applied without even removing them from their settings in rings and pins, this method proves of great practical service and value.

A pamphlet recently published by the Smithsonian Institution describes the system worked out by Dr. Wherry, in a technical manner calculated to interest the scientific student.

Chemical Lime

Some of the Technical Applications of This Economical and Useful Material

LIME has found a wide use in the chemical industries because it is the cheapest base known. Obviously, the kind of lime desired depends on the purpose for which it is to be used, and is therefore extremely variable. Thus, for some industries quicklime, hydrated lime, or ground limestone will be found equally suitable. Under some conditions either magnesian or high-calcium limes can be used with equal success; in other cases, the presence of magnesia in large proportions can not be tolerated. For most purposes the silica, iron, and alumina are to be considered merely as diluents, although they sometimes cause mechanical difficulties by forming a sludge which must be removed. If the lime is to be slaked before use and if the heat generated is not essential to the process, it will probably be found more economical to purchase hydrated lime, because it can be stored and handled with greater facility.

The uses of chemical limes are so numerous that it would be impossible to describe all of them, but a few of the more important ones can be outlined briefly.

SAND-LIME BRICK.

Sand-lime brick is a building material of growing importance. It consists essentially of a mixture of sand and lime, which is pressed into brick form and then treated with high pressure steam. The lime combines with a part of the sand, forming a calcium silicate, which binds the rest of the sand together. The lime must be completely hydrated before the mixture is pressed, or else the subsequent hydration and expansion will distort or disrupt the brick.

A process has been patented for making sand-lime brick from a magnesian lime, but did not prove successful because it was found impracticable to hydrate the magnesia completely before the brick were pressed.[1] Most of the purchasers of hydrated lime do not demand absolutely complete hydration, so that the manufacturers have not been called upon to give serious attention to this problem. Commercial hydrated lime sometimes contains small percentages of quicklime. For this reason, the manufacturer of sand-lime brick has found it safer to buy quicklime and hydrate it himself.

The presence of small amounts of impurities, especially silica or kaolin, in the lime has been found to be beneficial.[2]

GLASS.

Calcium oxide is a necessary constituent of plate, sheet, and bottle glass, and of a large proportion of the pressed and blown glass. It acts as a flux. Magnesia makes the glass more difficult to melt[3] but is sometimes a valuable constituent when particular optical properties are to be obtained. The calcium oxide is generally introduced as ground limestone, but the use of lime or hydrated lime is sometimes necessary in order to avoid the evolution of gas at high temperatures.

The ordinary impurities of limestone are, in general, of no importance to the manufacturer of common glass. For white glass, however, the content of oxide of iron must be less than 0.3 per cent of the stone.[4]

CERAMICS.

Lime and magnesia, generally as carbonates, are used to some extent as fluxes in the manufacture of pottery and porcelain. It has been found that for wares burned at moderate temperatures, calcium oxide tends to bring the points of vitrification and fusion close together, whereas magnesia tends to separate them, to lower the temperature of vitrification, and to decrease the change of shape due to burning.[5] On the other hand, if the ware is to be burned at higher temperatures, magnesia has little effect on vitrification and fusion and increases the shrinkage.[6] In a series of experiments to determine the values of different bases when used as fluxes for a mixture of feldspar, flint, and clay, it was found that magnesia gave the best results of the five bases tried (oxides of calcium, magnesium, barium, strontium, and zinc). It gave excellent color, high tensile strength, and only moderate shrinkage.[7]

These results all indicate that magnesia is better than calcium oxide as a flux for ceramic bodies.

The carbonates are generally used, since they are the cheapest forms. Levigated natural whiting is preferred on account of high colloidal content.[8]

In some cases, however, vitrification sets in before the carbonates are all decomposed and further evolution of gas may cause pinholing or internal strain. Under these circumstances it is necessary to use either the oxide or the hydrate. It is sometimes desirable to use the carbonates in wares burned at lower temperatures in order to obtain a porous body.[9]

Since the quantity of carbonate used is generally small and the chemical composition of the mixture may vary slightly, it follows that the impurities generally found in limestones are entirely negligible.

In glazes, magnesium oxide tends to absorb SO_2 from the kiln gases with production of a scum appearance. Although this can be overcome by skillful firing, it makes a low magnesia content desirable in most glazes.

WATER SOFTENING.

"Temporary hardness" of water is caused by the presence of calcium carbonate. This substance is practically insoluble in pure water, but is held in solution by the presence of carbon dioxide, which is found in practically all natural water. If this carbon dioxide is removed, the calcium carbonate will be thrown out of solution. The carbonic acid may be removed by boiling, but it is cheaper to neutralize it with lime. The lime reacts with the carbon dioxide to form calcium carbonate and, since the carbon dioxide is thus removed, this calcium carbonate, together with that originally present in the water, will be removed by the same process, the magnesium oxide in the lime will take no part in the reaction and must be considered as an impurity.

According to the usual method of procedure the lime is slaked to a cream, which is fed in an automatically regulated stream into the main body of water. Experience has shown that a well-burned, high-calcium lime will produce the greatest quantity of cream, which is also of better quality, because the lime stays in suspension longer and can be more thoroughly disseminated throughout the main body of water.

SODA ASH AND CAUSTIC SODA.

Most of the soda ash sold in this country is made by the "ammonia-soda" process. A solution of common salt is saturated with ammonia, and the mixture is treated with carbon dioxide. When the resultant solution is evaporated the soda ash is obtained by crystallization. Ammonia is expensive, and consequently the gas must be recovered and used over again. For this purpose the mother liquor is treated with lime and distilled. The lime replaces the ammonia in its compounds, and thus the gas is set free to distill off.

It is evident that this industry demands limestone, for both the lime and the carbon dioxide are used. The impurities in the stone are not harmful. It would seem that magnesium oxide should be as effective as calcium oxide in breaking up the compounds of ammonia, yet Lunge makes the statement that "magnesium limestone is not suitable for this industry."[10]

Caustic soda is made by dissolving soda ash in water and adding lime. Insoluble calcium carbonate is precipitated, and caustic soda is left in solution. In this reaction the magnesia is entirely inert.[11] The impurities are undesirable because they form a gelatinous precipitate which does not settle clear, and therefore leads to a contamination of the finished product. In this industry quicklime is preferable to hydrated lime because it hastens the reaction.

BLEACHING POWDER.

Bleaching powder is an oxychloride of calcium which is formed by the action of chlorine gas on moist slaked lime. The resultant product is sold on the basis of available chlorine. Any impurities in the lime will lower the quantity of the chlorine absorbed, and consequently the value of the product. Magnesia is especially objectionable because it forms magnesium chloride.[12] This substance absorbs water from the air and makes the powder sticky and hard to handle.

Hydrated lime is better suited for this industry than quicklime, because it contains fewer impurities, is easier to handle, and requires no preparation before using.

CALCIUM CARBIDE.

This substance, the source of acetylene, is made by heating a mixture of lime and coke in an electric furnace. For this purpose the only useful ingredient of the lime is calcium oxide.[13] Magnesia and other impurities are objectionable because the whole charge must be fused, and electric power is too expensive to waste it by heating useless material. For the same reason, quicklime is preferable to either hydrated lime or limestone.

ILLUMINATING GAS AND AMMONIA.

When illuminating gas is made by the distillation of coal, the crude product contains, among other compounds, carbon dioxide, hydrogen sulphide, and hydrocyanic acid. All of these would be objectionable to the consumer. Their removal may be affected by passing the gas through layers of moist slaked lime. For this purpose calcium oxide only is useful, although the magnesia and impurities are not harmful.[14] Hydrated lime is to be preferred to quicklime, because it is easier to handle and requires no preparation.

Crude coal gas is the chief source of ammonia. This is removed by washing the gas with water before it has reached the lime purifiers. The solution thus obtained carries both free ammonia gas and some compounds of ammonia. The free gas is driven off by heat and collected. Lime is then added to break up the compounds and the ammonia thus liberated is also distilled and collected.

Calcium and magnesium oxides should act with equal facility in liberating the ammonia, but, according to Lunge, magnesium limestone is not applicable to this industry. The impurities are not harmful. Either quick or hydrated lime may be used, with little advantage in favor of either.

CALCIUM CYANAMIDE AND CALCIUM NITRATE.

These substances, known technically as "lime- nitrogen" and "nitrate-lime" have recently been put on the market as commercial fertilizers. They represent means of converting the nitrogen of the air into plant food.

Calcium cyanamide is prepared by heating a mixture of lime and coke in an electric arc furnace, and treating the fused mass with nitrogen. The nitrogen is obtained from the fractional distillation of liquid air. Pure, high-calcium quicklime is required for this industry.[15] Any impurities are undesirable on account of the expense required to heat them.

If air is passed through an electric arc, the nitrogen and oxygen contained in it will combine. The oxide of nitrogen thus formed, when dissolved in water, produces nitric acid. This will combine with any base to form the corresponding nitrate. Since lime is the cheapest of all bases, and has a fertilizing value of its own, it is obviously the base to use. Hence calcium nitrate is formed. Magnesia acts in a similar manner, and its use is dependent on whether or not it would be harmful as a fertilizer. The presence of impurities in the lime is a matter of indifference, and quicklime, hydrated lime, or limestone will produce identical results. Hydrated lime is probably the most economical.

SPRAYING.

Lime enters into the preparation of a number of insecticides used in spraying vegetation. For such purpose calcium oxide is the only useful constituent of the lime. Magnesia and impurities are not harmful. The physical quality of the lime is of paramount importance. The material is sprayed on the vegetation through some form of atomizer, and therefore must contain no coarse particles or grit. For this reason hydrated lime screened to pass 150 or 200 mesh (a commercial article) would certainly give better satisfaction than lump lime.

SUGAR.

In the manufacture of sugar, both carbon dioxide and lime are used. Therefore, sugar manufacturers prefer to buy limestone and burn their own lime.

The juice extracted from either sugar beet or sugar cane contains various impurities. Some of these could discolor the sugar, and others (organic acids) would invert it, that is they would change the sugar into uncrystallizable glucose, and thus reduce the yield. In order to remove these impurities the juice is heated almost to boiling in the presence of an excess of lime. This lime combines with the acids, breaks up the other organic compounds, and forms insoluble salts. But it also forms an insoluble compound with sugar itself. For this reason after the lime has completed its action, carbon dioxide is forced into the liquid. This breaks up the combination between the lime and the sugar, and throws down all the lime as calcium carbonate. This precipitate carries with it all suspended matter, leaving a clear solution of sugar.

For these purposes calcium oxide only is useful. Im-

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[10] Lunge, George, Manufacture of sulphuric acid and alkali, 2d ed., vol. 3, p. 37, 1891-1896.

[11] Idem, vol. 2, p. 799.

[12] Idem, vol. 3, p. 440.

[13] Thompson, G. F., Acetylene gas and calcium carbide, p. 47, 1898.

[14] Hunt, Charles, Gas lighting, p. 136, 1900.

[15] Kershaw, J. B. C., Calcium cyanamide: *The Electrician*, vol. 60, p. 548, 1907-1908.

purities are apt to cause trouble. Thus, magnesium carbonate is more soluble in sugar solutions than calcium carbonate, and the salt so dissolved is later deposited on the tubes in the evaporating pans, thus making it necessary to clean them more frequently. Any silica present is thrown down as a gelatinous precipitate. This becomes a general nuisance by coating the cloth in the filter presses.[16]

DISTILLATION OF WOOD.

The destructive distillation of wood gives rise to four products: Gas, pyroligneous acid, tar, and charcoal. Of these pyroligneous acid is of most interest to the lime manufacturer. From this solution are prepared wood alcohol, acetic acid, and acetone, and lime is an essential ingredient in the manufacture of all these. First, the crude acid is treated with an excess of lime and distilled. Wood alcohol passes over, but acetic acid is held in the still in chemical combination with the lime. This mixture is known as "gray acetate of lime." Acetone may be produced from it simply by dry distillation; or it may be treated with sulphuric acid and the acetic acid distilled off. The wood alcohol is again treated with lime and redistilled in order to purify it.

For any of these purposes calcium oxide is the only useful constituent of the lime.[17] Magnesia and impurities are not harmful. Hydrated lime may be used instead of quicklime for any of these purposes, except the final distillation of wood alcohol. For other purposes probably neither substance has any advantage over the other.

PAPER.

Wood pulp for the manufacture of paper is prepared by one of three processes—mechanical, soda, and sulphite, of which only the second and third interest the lime manufacturer.

In the soda process lime is used to causticize sodium carbonate, thus recovering the caustic soda used in cooking the wood.

Calcium oxide is the only constituent of the lime useful in the soda-pulp industry. The magnesia and the impurities are not harmful. Hydrated lime may be used instead of lump lime, but the latter is to be preferred, since the heat generated by its slaking hastens the reaction with the soda.

Another solution which may be used in place of caustic soda for dissolving the cementing constituents of wood is "bisulphite liquor." This is a mixture of calcium and magnesium bisulphites held in solution by an excess of sulphur dioxide. The liquor is prepared by one of two methods: Limestone may be subjected to the solvent action of sulphur dioxide and water, or milk of lime may be treated with sulphur dioxide; the resultant solution is the same in either case.

For the maker of sulphite pulp magnesia is a desirable constituent of the lime or limestone. Magnesium sulphite is more soluble than calcium sulphite (100 parts of water dissolving 1.25 parts of the former or 0.0043 parts of the latter), and consequently permits of making a stronger liquor. Moreover, the presence of magnesia in the liquor gives the pulp a better color and makes it softer to the touch, so that it will felt together better when made into paper. Therefore, magnesian lime is much preferable to the high-calcium lime. The impurities are not harmful.

If limestone is used, it should be as porous as possible to permit a rapid solution.

Hydrated [illegible]me is preferable to lump lime, because it is easier to [illegible]le and contains fewer impurities.

PAINTS.

Ground lim[illegible] [illegible]ked lime, levigated chalk (natural whiting), and [illegible]cally precipitated calcium carbonate are used to a large extent in the paint and allied industries. For these purposes fineness of grain is essential; sometimes the color or chemical composition is of equal importance. It is difficult to obtain a limestone of sufficient whiteness or to grind it sufficiently fine to meet the requ[illegible]ments. It is th[illegible]efore an advantage to use air-slak[illegible] [illegible]ime or hydrated lime.

Cold [illegible]er paints consist essentially of hydrated lime, pigments, and casein ground together. From the nature of the substances it is obviously impossible to use quicklime, and magnesian hydrates are probably to be preferred over high-calcium hydrates on account of their better spreading qualities.

GLYCERINE, LUBRICANTS, AND CANDLES.

Most common fats are compounds of glycerine with various organic acids. These compounds can be broken up by heating the fat with lime and water under pressure. The glycerine is liberated, and the lime takes its place in the compounds. Practically all of the glycerine used in this country (mostly in the manufacture of explosives) is made in this way. The lime "soaps" formed by this process are sometimes mixed with heavy mineral oils and sold as lubricants or greases. They are of especial value for the lubrication of heavy machinery or for use at high temperatures. The soaps may be treated with sulphuric acid; the separated fatty acids are recovered and used in the manufacture of soap and allied products.

Calcium oxide is the only useful constituent of the lime, although the magnesia and impurities are not harmful.[18] Quicklime is probably preferable to hydrated lime, because the heat of slaking can be used.

TANNING.

In the leather industry lime is used in the "depilation" process. The hair is so loosened from the hide by soaking it in lime water that it can be removed by subsequent scraping. In regard to the quality of lime to be used the following statement is made:

"The presence of magnesia and clay is injurious, not only by diminishing the amount of lime present, but by making the lime much more difficult to slake; and iron oxides, though quite insoluble, may become mechanically fixed in the grain of the hide, and may be the cause of subsequent stains."[19]

The use of hydrated lime would remove the above objections to magnesia, but not those to iron. Hydrated lime is probably preferable to quicklime for this reason, as well as for the fact that it is easier to handle.

For some particular grades of leather, such as morocco, the presence of magnesia has been found to be advantageous.

In addition to the uses outlined, limestone, quicklime, and hydrated lime play a part of more or less importance in a large number of industries, among which may be mentioned the following:[20]

The manufacture of dichromates, magnesia, bone ash, glue, and varnish; as a refining and purifying agent in the distillation of mercury, in the clarification of grain, in refining fats, greases, butter, linseed oil, and petroleum, in preserving eggs, and as a general disinfecting and deodorizing agent; as a filler in the paper, textile, linoleum, and rubber industries; as a mordant in dyeing; as an abrasive in polishing; in the manufacture of calcium-light pencils; and of magnesium for flashlight powders; as limewater in medicine; for the recovery of potassium cyanide used in extracting gold and silver from their ores; to neutralize the sulphuric acid used in pickling steel; and in a large number of other industries.—*Mineral Resources U. S., Part II, U. S. Geological Survey.*

Treating Porous Cement

A NEW method of stopping porous cement work, and neutralizing the free lime, which is said to give excellent results, is as follows, according to *The Engineer*. The surface of the work is painted with a solution of 8¾ pounds of zinc sulphate in a gallon of water. A reaction between the zinc sulphate and the free lime occurs as deeply as the solution penetrates, and by it the insoluble neutral salts, calcium sulphate, and zinc hydroxide are precipitated into the pores. This priming coat should be given some ninety-six hours to dry, the surface then being brushed and painted with two coats of a good cement paint.

Petroleum Prospects in Chile*

FOR many years emanations of inflammable gases have been observed in the neighborhood of Punta Arenas and in Tierra del Fuego. These gaseous emanations led to several drilling enterprises in search of petroleum which were without result. In October of 1912 a considerable volume of natural gas was found at the depth of 300 feet, about 1 mile west of Punta Arenas, near Minas River. Films of oil were also noticed on the water brought up by the pumps from this well. On the strength of these discoveries the minister of industry and public works commissioned Prof. E. Miers and Dr. Johannes Felsch, geologist to the minister of industry and public works, to make a geologic study of the region. The following is a *résumé* of the results obtained in this work: Inflammable gases are found in Quemas Malas; on Tres Brazos River, from lower Tertiary clays; on Minas River; near Cape Boqueron in Tres Puentas River; at Pecket Harbor, from sands of the upper Tertiary, and from Otway Gulf. The strata holding the gases are of different ages, but all lie in or below the Tertiary.

In the valleys of Tres Puentas River and of Tres Brazos River and at Cape Boqueron seepages of gas are found in connection with petroliferous rocks, in the immediate vicinity of Tres Brazos River, of Tres Minas, and of Tres Puentes River. In these regions faults have been noted. They probably exist also near Cape Boqueron and picket Harbor. Anticlines are found at Quemas Malas and to the north of Cape Yartau in Whiteside Channel. It is also believed that the petroleum will be found in the Cretaceous beds or in still older rocks.

The existence of petroleum has been definitely shown near Punta Arenas and northwest of Tierra del Fuego. The frequency of the emanations of natural gas makes it probable that the petroliferous deposits are large. The geologists have indicated to certain proposed drilling companies the most appropriate places for drilling. The State takes no part in actual drilling, but will continue to further scientific explorations with a view to giving all aid to the search for petroleum.

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* From the report of the United States Geological Survey on the Production of Petroleum in 1913.

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